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OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. CIV. JULY, 1877. No. 1.

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Franklin Institute.

HALL OF THE INSTITUTE, June 20th, 1877.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 104 members and 7 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at their last meeting, the action of the Committee on Science and the Arts, recommending the award of the Elliott Cresson Gold Medal to John Charleton, for his Internal Clamp Coupling; and the Scott Legacy Premium and Medal to Thos. Shaw, for his Spiral Exhaust Nozzle, was approved; and that these medals will be awarded and delivered to said parties at the end of three months, unless, within that time, satisfactory evidence of want of originality be lodged with the Actuary. Also, that 8 persons were elected members of the Institute, and the following donations were made to the library:

Plano Telegrafico de la ysla de Cuba, por D Eurique de Arantave.

Annals of the Astronomical Observatory of Harvard College. Vol. 1, Pt. 1, to Vol. 4, Pt. 1, and Vol. 5. From Harvard College Observatory.

Specifications and drawings of Patents issued from the United States Patent Office, for November, 1876. From the office.

The Queenslander. Brisbane, February 17th, 1877. From Hector Orr.

Report of progress in the Counties of York, Adams, etc., etc., by Persifor Frazer, Jr. Harrisburg, 1877. 2d geological survey of Pennsylvania, 1875.

Report of progress in the Cambria and Somerset district of the Bituminous coal fields of Western Pennsylvania, by F. & W. G. Platt. Pt. 1, Cambria. Harrisburg, 1877.

Special report on the Coke Manufacture of the Youghiogheny river valley, by F. Platt. Harrisburg, 1876.

From the Board of Commissioners of the Survey.

Narrow gauge locomotives. Baldwin Locomotive Works. Philadelphia, 1877.

Exhibit of locomotives, by Burnham, Parry, Williams & Co Philadelphia, 1876. From the Works.

Verhandlungen des Naturhistorisch, Medicinischen Verein zu Heidelberg. 5th Pt., 1st Vol., New Ser., 1877. From the Union.

Catalogue of chemicals, chemical apparatus, etc. 13th Edition, 1876. From Bullock & Crenshaw.

Report of the joint committee (of the Ohio Legislature) concerning the Ashtabula bridge disaster, 1877. From M. Barnes, Secretary of State.

On a peculiar type of eruptive mountains in Colorado, by A. C. Pearle, M.D. From the Author.

Contributions to the Centennial Exhibition, by John Ericsson, New York. From the Author.

Fifty-seventh anniversary celebration of the Mechanic Apprentices' Library Association, in Mechanics' Hall, February 22d, 1877. Boston, Mass. From the Association.

Supplement to the report of the Permanent Committee of the first Intern. Congress, at Vienna. From the Meteorol. Com. Royal Soc.

Geological exploration of the 40th parallel, made by order of the Secretary of War, by C. King. From the Engineers' Dept., Wash.

Map showing the relative preponderance of Nationalities in Turkey.

Schedler's map of the Black Sea, Asia Minor, etc., etc.

Schedler's maps of Dobrudsha, Central Roumania and Bessarabia, also of Western Bulgaria, Roumania, etc., with a special map of the seat of war in Asia Minor.

Schedler's map of Turkey and Greece.

From Charles Bullock.

Kentucky Geological Survey. Resources of Kentucky.

Bayer & Co. Barmen und Elberfeld.

Bicarbonate of Soda. Penna. Salt Manuf. Co.

Le Chili, tel qu'il est. 1876.

Descriptive Catalogue of collection of economic minerals of Canada, etc., etc. 1876.

Catalogue of the Chilian Exhibit, at Centennial Exhibition, 1876. From Prof. Thomas, N. J.

Annual report of Friends' Free Reading Room and Library. Germantown, 1877. From the Librarian.

Report of the U. S. Commission of Fish and Fisheries. 1873–75. Washington. From the Smithsonian Institution.

Seventh annual report of the Board of Commissioners of Public Charities of the State of Penna. Harrisburg, 1877.

Report of the Transactions of the Penna. State Agricultural Society, for 1876. Vol. II. Harrisburg, 1876.

Annual report of the Secretary of Internal Affairs, of the Commonwealth of Penna., for 1876. Pt. 1, Land office, Pt. 2, Assessments. Harrisburg, 1877.

From A. K. Dunkel.

Minutes of Proceedings of the Institution of Civil Engineers. Vol. 48. Sess. 1876–77. Pt. 2. London, 1877. From the Institution.

Report on a developing school and school shops, by a committee appointed by the American Social Science Association. Boston, January 10th, 1877. From the Association.

On repulsion resulting from radiation. Preliminary note on the Atheoscope, by Wm. Crookes. London, 1877. From the Author.

Account of the manners of the German inhabitants of Pennsylvania, written 1789, by B. Rush. Notes added by Prof. I. D. Rupp. Phila., 1875. From Prof. Rupp.

[Donations continued in next number.]

The following papers were then read: one by Mr. S. F. Gates, on Weights and Measures, read by the Secretary; and one by Mr. J. T. Wainwright, read by the author.

Mr. Robert Briggs, in a note, wished the Secretary "to bring to the "attention of the members present, an exhaustive article of mine in "the JOURNAL for April, 1876,[i] which I think covers the effect of "extra length in steam boilers, with much completeness, as well as "showing the resulting effect on the draft of the chimney."

Mr. J. W. Nystrom called attention to the exhaustive experiments made by the Société Alsacienne de Construction Mechaniques of Mulhouse, in which the boiler having the least heating surface gave the best results.

The Secretary presented his report embracing the following subjects: Lieut. C. A. L. Totten's Compensating-Powder for heavy artillery[ii]; E. LeFranc's Decorticator for ramé, jute, hemp, etc.; Mr. J. H. Cooper's Mechanical Movement for changing continuous rotary motion into intermittent rotary motion; a Balance Slide Valve by the same inventor; Dr. F. J. Delker's Water-Filter; and a note on the Traction of Locomotives.

The President called the Vice-President to the chair, to make some remarks, and the latter presided during the remainder of the meeting.

Mr. J. B. Knight, representative of the Franklin Institute in the Board of Trustees of the Pennsylvania Museum and School of Industrial Art, presented a report of the progress making by that institution.[iii]

A note from Mr. Robert Briggs was read, calling attention to a premium offered by the American Philosophical Society, for a process for successfully utilizing anthracite coal-dust.

The Secretary gave notice that as the time for the next stated meeting of the Committee on Science and the Arts, falls on the 4th of July, the meeting has been adjourned to the first Wednesday in August next.

Prof. J. Ennis offered a series of preambles and resolutions upon the subject of teaching "science in common schools and by public lectures," which, on motion of Dr. Rogers, amended by Mr. Orr, were referred to the Committee on Primary Industrial Education.

On motion, the meeting adjourned.

J. B. KNIGHT, *Secretary.*

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[i] JOUR. FRANK. INSTITUTE, 3d Series, Vol. lxxi, p. 246.

[ii] See page 54.

[iii] See page 6.

CORROSION OF PROPELLER BLADES.

Extract from the Secretary's Report, at the Meeting of the Franklin Institute held May 16th, 1877.

Your attention is called to a remarkable corrosion of the cast iron propeller blades of transatlantic steamers, by these pieces taken from one of the American Line ships, and to this image projected on the screen, of another blade, showing its peculiar location.

The view shown is the forward or following side of the blade, and the corroded portion is next the entering edge, and extends about half the width of the blade at the outer end, and to an irregular line drawn diagonally across to the entering edge, about half its length. Along the edge, however, there is a space about 1½ inches wide, which is not at all corroded. About 20 inches from the outer end, and midway of the width of the blade, is a hole 1½ inches diameter used for handling the blade, and through this the water passes when the propeller is in motion. The interior of this hole is not corroded, but the surface of the blade on the side opposite to the direction of its motion is deeply pitted, sometimes to the depth of half an inch. Nowhere else is there any appearance of corrosion, the paint on the remaining portion of the following side of the blade being still visible after three years' service, and that on the after or thrust-face being worn away by the friction of the water. In one case the outer end of the blade was eaten away to such an extent that a piece of about one square foot area, broke off by the action against the water, showing a thickness of solid metal of less than half an inch. These blades were made of No. 1 cold blast charcoal pig-iron, and were cast with the now corroded face downwards. Eleven of these have been broken up for smelting, and there is no evidence of imperfections in the casting. The propellers from which they were taken are 17 feet diameter, 24 feet pitch, and make 60 revolutions when in service; the width of the blade is 3½ inches. This action is found on all steamers making transatlantic voyages, but has not been observed on our coastwise steamers.

What is the cause of this corrosion, and why it always selects this particular spot for its action, are very interesting questions. K.

THE PENNSYLVANIA MUSEUM AND SCHOOL OF INDUSTRIAL ART.

Report of the Representative of the Franklin Institute, at the Meeting held June 20, 1877.

Since my last report in January last,[1] arrangements have been perfected by which the Museum authorities have been placed in formal possession of Memorial Hall; and with a sum of money appropriated by the Centennial Board of Finance, the building has been put in condition to receive the collections of the Museum. These collections, the nucleus of which was formed at the Centennial, have been materially increased by purchases since made, and by loans from Europe.

Two leading London firms have sent, on loan for one year, representative collections; one of English pottery, and the other of French pottery and glass. These additions to the collection of works already owned by the museum, together with the collection of Spanish pottery and glass loaned by Signor Riaño, make the department of ceramic and glass work almost complete, and present a valuable opportunity of study to our potters and glass-makers, which, if taken advantage of, will tend to greatly improve those important and growing industries.

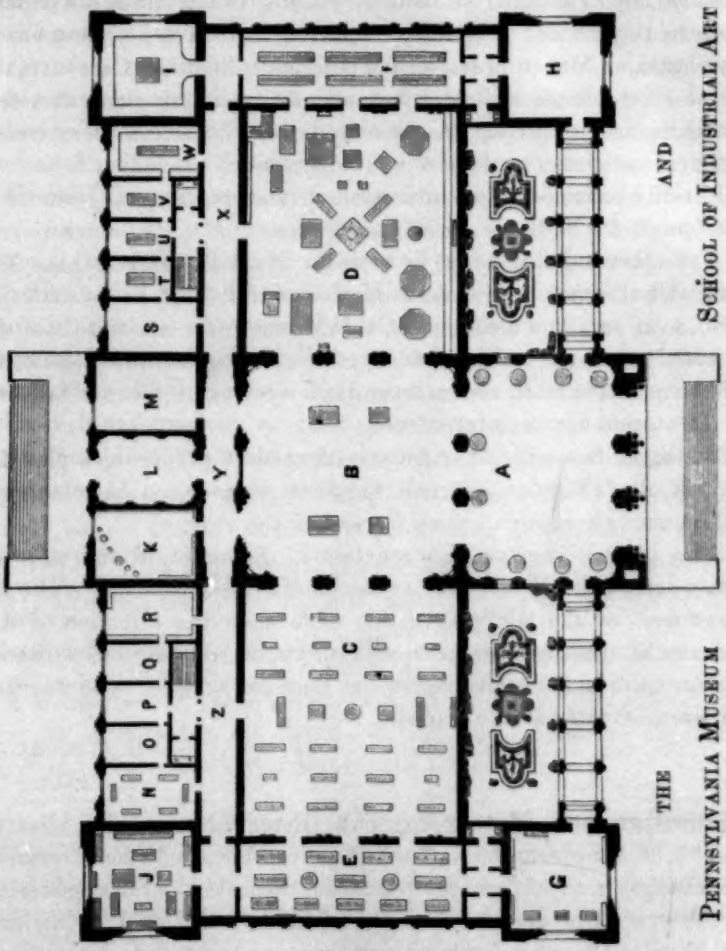
The works in the precious metals, with the electrotype reproductions, are, together with the ceramic and glass objects, placed in the large west gallery, C. There is also in this room the collection of Persian art, selected with great care, in Persia, by Mr. Caspar Clarke, and presenting the application to various materials of the deservedly admired Oriental design and coloring.

In the west saloon, E, the India collection is arranged in its entirety, comprising a complete collection of specimens illustrating the products and manufactures of India.

The northwest pavilion, J, is devoted to the textile fabrics and embroideries. This department has been also greatly added to, and now contains valuable specimens of various ages, most important as studies for the designer and manufacturer. In the southwest pavilion, G, there are now being arranged the specimens of wood-work, iron-work, casts of architectural ornament, and all that relates to the subject of art applied to building and the construction of domestic articles.

[1] See Vol. ciii, page 85; February, 1877.

Along the walls of the west corridor, Z, is hung the framed material, consisting of drawings, lithographs, and photographs of art objects, which, in the absence of the originals, suffice to instruct the student and interest the casual visitor. The rooms opening on the corridor will be utilized as follows: M contains miscellaneous objects,



on loan; O, P, Q, offices; R, the library and room for consultation of works of reference. The rotunda, B, is reserved for the larger objects of the various collections, as the light is so high that smaller specimens could not well be studied.

The entire eastern portion of the building has been set apart for the display of the collections of the American Institute of Mining Engineers, and will shortly be opened to the public.

As the arrangement of mineral and metallurgical specimens rapidly progresses, it becomes more and more evident that they will form the most valuable collection of the kind in this country, and its importance to the student cannot be overestimated. To the specimens of European production presented to the Institute at the Centennial, is added most complete illustrations of our own mining and manufacturing industries, giving an opportunity of comparison of materials and processes most instructive and important.

In order to facilitate the admission of visitors, an arrangement has been concluded with the Permanent Exhibition Co., by which tickets sold at either building admit to both the Main Building and the Museum and all other collections in Memorial Hall.

So soon as the collections of the Museum are arranged to the satisfaction of the officers, descriptive catalogues and handbooks will be published; in the meanwhile, a system of distinct labeling of the objects has been introduced.

The committee on instruction are engaged in preparing a plan for the schools, which, if sufficient financial support can be obtained, will be put in operation before the end of the year.

I am pleased to report, in conclusion, the practical and comprehensive character of all that has been so far accomplished in the establishment of the Museum, and to urge upon the attention of the members of the Institute the fact that the interests of the mechanic arts are so intimately involved in the Museum scheme, as to warrant the warmest interest and support.

J. B. KNIGHT.

Simultaneous Meteorological Observations.—M. Alluard, director of the observatory of the Puy-de-Dôme, finds some remarkable changes in the differences of pressure indicated by self-registering barometers. One was placed on the summit of the Puy-de-Dôme and the other at Clermont-Ferrand, and on comparing the simultaneous records, discrepancies were found, which could neither be explained by the variations of temperature nor by Laplace's formulæ for the barometric determination of altitudes.—*Les Mondes*, April 19.

C.

CORRESPONDENCE.

NEW YORK, June 5th, 1877.

Editor of Franklin Institute Journal:

Having been shown a republication of a late controversy in the *Scientific American*, on the Force of Falling Bodies, I find that one of the parties has seen fit to adopt my formula therefor, whereupon an opponent is pleased to charge him with being "misled by Haswell," inasmuch as he had attained his result by the formula $W v 4{\cdot}426 = M$. I therefore feel called upon to defend the party who has confided in me, and I submit the following:

Having long entertained the conviction of the error of the ordinary formula for the computation of the impact of a body falling freely, I, in 1852, instituted a series of experiments, having in view a determination of the impact by actual operations; for a detailed report of them, see Appleton's *Mechanics' Magazine*, Vol. II, p. 281, the result of which established the following:

1st. That the dynamical effect, or measure of impact, is directly as the velocity acquired, or, that at the termination of the stroke.

2d. That one pound falling freely through a space of one foot, and having consequently a velocity of $\sqrt{1 \times 2g} = 8{\cdot}02$ feet per second, had an impact of 35·5 lbs., and that in falling 2 feet, having a velocity of $\sqrt{2 \times 2g} = 11{\cdot}34$ feet per second, had an impact of 50 lbs., and in like manner other weights, and at different heights of fall, furnished like results. Hence, $\frac{M}{W \times v}$ or $\frac{35{\cdot}5}{1 \times 5{\cdot}02} = 4{\cdot}426$.

A comparison of these results with those deduced by the various formulæ submitted in the discussion, and which embrace all that I recollect to have met with, presents the following:

WEIGHT AND HEIGHT OF FALL.	FORMULÆ OF W. H. P. $W \times h = M$	G. M. T. $W \times v = M$	P. H. Vander Weyde. $W \times v^2 = M$.	J. W. Nystrom. $\frac{W \times h}{d} = M$	Experiment.
	LBS.	LBS.	LBS.	LBS.	LBS.
1 lb. falling 1 ft.	1	8·02	64·33	2	35·5
1 lb. falling 2 ft.	2	11·34	122·66	4	50

W representing the weight of the falling body, h the height or

space fallen through, v the velocity in feet per second, d the distance an impinged body, as a nail, would be driven in inches—in this case ·5 inch is assumed—and M the effect, or moment of the impact.

In the experiments referred to I did not essay to attain the exact factor or multiplier of the weight, whereby to compute the impact, as I well knew my instrument was not equal to the requirements, but my purpose was to ascertain what was the general relation between velocity and impact, and in this particular I claim to have succeeded; whether the factor was 4·426 or 4·5 times, it mattered but little. I had made a successful step in a right direction, and with sufficient accuracy to meet the demands of practical operations.

In consequence of the great variety of formulæ as presented above, and the confident manner in which they are set forth, I have been induced to renew my experiments, and I again submit them, with a knowledge of their integrity and of the correctness of their deduction.

It is to be regretted that my instrument necessitated the weight to be arrested by a cord, as the tension thereof was at the expense of the impact of the weight; but in order to remedy this so far as practicable, without the construction of an instrument capable of admitting the weight to fall freely, and to be arrested only at the termination of the stroke, I used cords of hard-laid and long-used fish-line, laid up *selvagee*, and very flexible.

What the exact factor is I know not, but my impression is it will be fully 5 times the velocity.

Respectfully,

CHAS. H. HASWELL, C. & M. E.

Microseismic Observations.—Father Bertelli, after discussing more than 20,000 observations, made from 1870 to 1875, reaches the following conclusions: The oscillations of isolated pendulums are generally parallel or perpendicular to the axes of valleys or mountain-chains. The oscillations are not dependent upon local vibratory movements, nor on the velocity or direction of the wind, nor on rains, nor on thermometric or electric changes. The tromometric movements are most vertical at the time of earthquakes. The positions of the sun and moon seem to influence the movements of the pendulums, but they are especially frequent when the barometer is low. C.

Aniline Black.—M. A. Rosenstiehl closes a historical note as follows: Whenever one wishes to obtain, economically and regularly, aniline black upon tissue, the simultaneous co-operation of a chlorate and of a metallic substance is indispensable. In practice, copper has been adopted for blacks, developed at a temperature of about 45° C., and iron for those which must undergo a steaming, or a temperature of 100°. But if the conditions of industrial labor are not imposed, an aniline black can be obtained upon tissue, without the aid of chlorates, or of a metallic substance, by the simple action of "nascent" or active oxygen. Blacks may likewise be obtained, independent of tissues, without the intervention of a metal, by the aid of chlorates; I have already proved that this fact has long been known. The work of M. Coquillion has just shown that, in this case also, the same result may be reached without chlorates. The fact observed by him is an elegant demonstration of the action of active oxygen upon aniline salts; it will, perhaps, enable us to obtain blacks derived from aniline in a state of greater purity, and to hasten the moment when we shall know their elementary composition, a question which, in view of its great interest, has been proposed for a prize by the Industrial Society of Mulhouse.—*Annales de Chimie et de Physique*, Aug., 1876. C.

Old Gallo-Roman Harbor.—At a very early date, the neighborhood of St.-Nazaire, between Ville-Halluard and Méans, formed a bay sown with islands. About the 5th century B. C., the bay of Penhouet was inhabited by a maritime population. This population, with dolichocephalous skulls, was contemporaneous with the aurochs and the stag; it used instruments and arms of horn, bronze, and stone. The bottom of the bay was then about four metres below the present low-water level. This harbor was probably the *Corbilo* of Polybius, cited by Strabo. In the 3d century of our era, the same banks were occupied by Gallo-Romans. The bay of Penhouet served again as a harbor, to which Ptolemy gave the name of *Brivates portus*, the port of Brivet. The bottom of the bay was then only one and a half metres below low water. Towards the 8th century A. D., the Brivet, meeting an obstacle in the muddy bed of Penhouet, changed its course at a distance of two kilometres above its mouth, and found a new outlet at Méans. These dates have been fixed by M. Al. Bertrand, by studying the mud-deposits.—*Acad. des Sciences*, April 9. C.

Berlin Pneumatic Dispatch.—The proposed pneumatic dispatch in Berlin embraces 26 kilometres of tube, and has 15 initial stations. The wrought iron tubes have a clear breadth of 65 millimetres, and lie about one metre below the surface of the ground. The letters and cards which are to be forwarded, have a prescribed size, and are enclosed in iron boxes, or cartridges, each of which can hold 20 letters or cards. In order that they may pack closely, they are covered with leather. From 10 to 15 cartridges are packed and forwarded at a time; behind the last cartridge is placed a box with a leather ruffle, in order to secure the best possible closure of the tube. At four of the stations are the machines and apparatus needed for the business. The forwarding of the boxes is effected either through compressed or rarefied air, or through a combination of the two. Steam-engines of about twelve horse-power are used for the condensation or exhaustion of the air. Each main station has two engines, which drive a compressing and an exhausting apparatus, the steam for each engine being furnished by two boilers. Large reservoirs are employed, both for the condensed and for the rarefied air. The former has a tension of about three atmospheres; the latter, of about 35 millimetres of mercury. The air, which is heated to 45° C. by the compression, is cooled again in double-walled cylinders which are surrounded by water. The velocity of the boxes averages 1000 metres per minute, and a train is dispatched every 15 minutes. Each of the two circuits is traversed in 20 minutes, including stoppages. The entire cost of the enterprise will be about 1,250,000 marks.—*Dr. Grüneberg, in Wochenschrift des Vereines Deutscher Ingenieure*, March 31. C.

Change of Cane Sugar into Glucose.—Mons. U. Gayon finds that raw sugars, like molasses, gradually exchange crystallizable for incrystallizable sugar, leading sometimes to a loss of 33 per cent. The change is accelerated by heat and moisture. It does not appear to be due to acidity but to a true fermentation.—*Acad. des Sciences*, C.

Phosphorescent Organic Bodies.—B. Radziszewski finds that the following bodies have the property of shining in the dark, as soon as they are put in contact with an alcoholic solution of caustic potash: hydrobenzamide, amarine, lophine, and the crude product of the action of alcoholic ammonia on benzile. C.

Rarchaert's Total Adherence Locomotive.—The scientific and technical portion of a late number[1] of the *Annales des Mines*, is wholly taken up by a memoir of M. Massieu, and a short note of the inventor, upon Rarchaert's "locomotive of total adherence and converging axles." The locomotive was first tried on a circuit of 58 kilometres, during which it behaved well in all points of view, reaching a mean velocity of 40 kilometres, and sometimes exceeding 50 kilometres per hour, on slopes of ·015 and in curves of 250 metres radius. After this trial, it was employed, for about two months, upon trains. M. Rarchaert finally obtained authority from the company to employ his machine on regular trains, under the charge of the company's engineers and stokers, the expenses being borne by him. This condition was so burdensome, that he terminated the trial at the end of a month. During that time the locomotive had traveled 4349 kilometres, and had satisfied all requirements without accident. It has since been employed on the road from Orleans to Chalons. M. Massieu and his principal subordinates carefully studied the details of construction and operation, and presented two successive reports, which he was invited, by the commission of the *Annales des Mines*, to embody in a single memoir, under the following heads:

1. Brief examination of the processes hitherto employed to facilitate the passage of locomotives on curves, with the more or less complete utilization of the adherence which their total weight can give.
2. Description of the apparatus.
3. Study of the apparatus in a kinematic point of view; examination of the conditions in which it can overcome the curves and irregularities of the track.
4. Study of the apparatus dynamically; examination of the causes which can impair its stability.
5. Comparison with other locomotives employed on secondary lines; results of the trials.
6. Examination of the objections against the use of a single and straight connecting rod.
7. Summary and conclusion.

The memoir covers 200 pages; M. Rarchaert's note, 12 pages. Both terminate with the following conclusion: "For a long time, the constructors of locomotives with a single motor, have tried to sepa-

[1] 5th livraison for 1876.

rately realize, sometimes total adherence, sometimes flexibility; sacrificing, according to circumstances, one of these conditions to the other. Among those who have tried to realize them both at once, I am led to believe that M. Rarchaert is the one who has best, and even for the first time, practically succeeded." C.

Phosphor-Tin and Phosphor-Bronze.—Phosphorus and tin combine in the most varied proportions, but if there is more than five per cent. of phosphorus, the alloy is broken up when remelted. The proportion of 95 per cent. tin and 5 per cent. phosphorus is so stable, that it remains unchanged, however often it may be remelted. Its melting point is about 500° C. It imparts its own stability to the bronze, which is made by the addition of proper proportions of copper. The well-ascertained influences of phosphorus upon bronze are: 1. The removal of all the metallic oxides in the bronze, and the consequent prevention of flaws, greater compactness, and increased solidity. 2. Phosphorus has a hardening influence on copper and tin; hence, copper alloyed with phosphor-tin gives a much harder bronze than with the same quantity of common tin, or one equally hard, with one-half the quantity. 3. The phosphorus makes the bronze more fluid, and the castings sharper. 4. The phosphorus increases the resisting capacity of the bronze, both against atmospheric influences and against acids.

The experiments of the English Admiralty have shown that sheathing of phosphor-bronze withstands the action of sea-water nearly three times as long as the best copper sheathing. The Austrian phosphor-tin, with 5 per cent. or 2½ per cent. of phosphorus, may be melted with copper precisely like common tin. Notwithstanding its high price, the bronze which is made from it is only about 8 per cent. dearer than common bronze, while it is 40 per cent. cheaper than the phosphor-bronze which is imported from England and Germany.— *Wochenschrift des Oester. Ingen.- u. Archit.-Ver.*, April 28. C.

Prevention of Boiler Scale.—Herr Clouth employs a caoutchouc lacquer, which prevents the adhesion of the sediment to the walls of the boiler, so that the scale can be easily removed. After the scaling the boiler is left bright and smooth. The lacquer does not injure the iron, for its ingredients are only linseed oil and india-rubber.—*Ibid.* C.

Utilization of Parchment-Paper Waste.—In the first April number of *Dingler's Polytechnic Journal*, C. O. Cech calls attention to the fact, that in the manufacture of parchment-paper, after the treatment with sulphuric acid there is a large amount of waste, which cannot be converted into paper, and which is commonly burned under the boilers. In a single factory this waste often ranges from 750 to 1500 kilogrammes per month. It is so rich in cellulose that it seems desirable to turn it to a more profitable use, and such use is suggested by the method introduced in 1857, by Roberts, Dale & Co., Warrington, for manufacturing oxalic acid by heating sawdust with caustic alkali. When the carriage of the waste is attended with small cost, it can probably be worked so as to yield a more profitable return than Tessié du Motay's patent method[1] for making oxalic acid from turnips, or the process of Possoz[11] for preparing it from wheat bran. The factory of Dr. Kunheim, in Berlin, which yearly makes 200 tons of oxalic acid from sawdust, has undertaken to give M. Cech's plan a thorough trial. C.

Acidity of the Gastric Fluid.—From experiments, by means of a gastric fistula, M. Ch. Richet concludes that: 1. The mean acidity of the gastric juice, whether pure or mixed with food, is about equivalent to 1·7 gr. of chlorhydric acid for 1000 gr. of liquid. He has never found the acidity less than ·5 gr. or greater than 3·2 gr. 2. The quantity of liquid in the stomach has no influence on its acidity; whether the stomach is nearly empty or overloaded with food, the acidity is nearly invariable. 3. Wine and alcohol increase the acidity; cane-sugar diminishes it. 4. If acid or alkaline liquids are thrown into the stomach, the gastric liquids tend very rapidly to recover their normal acidity, so that, by the end of an hour, the mean acidity is nearly restored. 5. The gastric fluid is most acid while digestion is going on. 6. The acidity increases slightly towards the end of digestion. 7. The sensations of hunger and thirst do not depend either upon the acidity or upon the fulness of the stomach. C.

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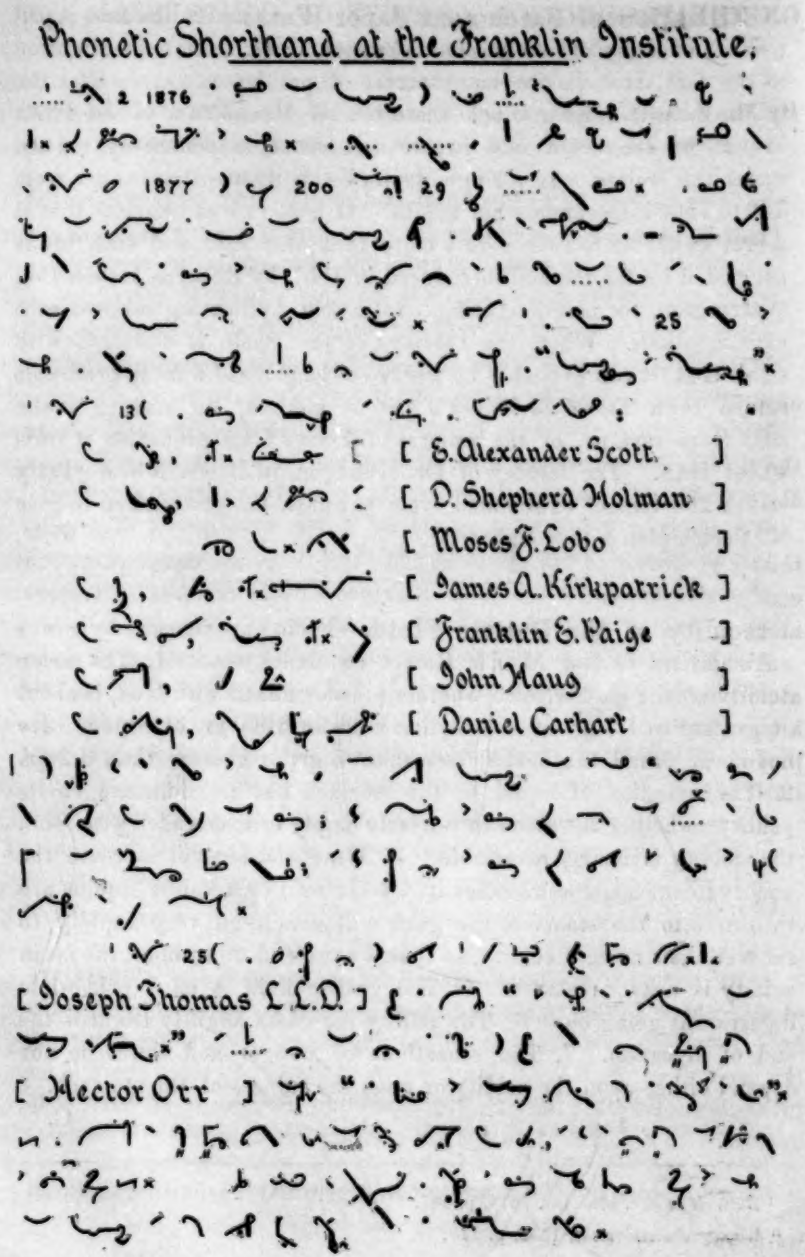
[1] *Bull. de la Soc. chimique*, 1874, p. 187.

[11] *Wagner Jahresbericht*, 1858, p. 110.

Phonetic Shorthand at the Franklin Institute.


[S. Alexander Scott]
[D. Shepherd Holman]
[Moses F. Lobo]
[James A. Kirkpatrick]
[Franklin S. Paige]
[John Haug]
[Daniel Carhart]
[Joseph Thomas L.L.D.]
[Hector Orr]

ON THE PRODUCTION AND USE OF COMPRESSED AIR IN MINING OPERATIONS.

By M. F. L. CORNET, Chief Engineer of the Mines of Eastern Flenu à Cuesmes, Cor. Member of the Scientific Section of the Royal Academy of Belgium.

[Translated from the French by ROBERT ZAHNER, Department of Engineering, Stevens Institute of Technology.]

[Continued from Vol. ciii, page 413.]

We have seen that it is water-spray that we propose to use for the absorption of heat during compression.

We would use the same means to provide the compressed air, at the time of its expansion, with the heat necessary to keep its temperature from falling below that of melting ice.

We admit, *a priori*, that, whatever be the quantity of heat contained in the air at the moment of its exit from the compressor, the cooling which it undergoes in the reservoir always restores its temperature to that of the atmosphere, *i. e.* to 20° C.

A cubic metre of atmospheric air, compressed to a tension of eight atmospheres, will yield, if expansion follows Mariotte's law, 31,756 kilogrammetres of work, of which 10,334 kilogrammetres are employed in overcoming atmospheric pressure. This work resolves itself into:—

(1.) The part realized at full pressure. This equals

$$10334 \times 8 \times 125 = 10334 \text{ k}^{\text{m}}.$$

(2.) The part yielded by expansion. This equals

$$31756 - 10334 = 21442 \text{ k}^{\text{m}}.$$

After, as well as before, expansion, the air is found at a temperature of 20°, since we have assumed that it follows Mariotte's law. No heat, therefore, is dissipated during expansion; but, as we secure at the same time 21,422 kilogrammetres of work, and since there is no production of work without a corresponding dissipation of heat, it is necessary to introduce into the air working expansively

$\frac{21442}{424} = 50{\cdot}52$ thermal units, a quantity equal to that which we found above for compression.

The quantity of heat which is to be abstracted from the air which is compressed, in order that the change of tension may follow Mariotte's law, is therefore precisely equal to that which must be supplied to it during expansion, if the latter shall follow the same law.

If we succeed, by the use of water-spray, in heating the expanding air sufficiently to bring its temperature again to that of the atmosphere, the water at its exit from the cylinder can evidently not have a temperature lower than that of the atmosphere. Again, there can be no heating of the air, if there be no surrender of heat by the water; and this surrender is possible only if the temperature of the water at its entrance is higher than at its exit. Consequently, to keep the temperature of the expanding air from falling below that of the atmosphere, it is necessary that it have at its disposal water whose temperature exceeds that of the surrounding air.

Now as the water met with in mines is mostly of a temperature equal to, or lower than, that of the air of the galleries, we cannot consider it possible, in practice, to cause the compressed air to expand according to Mariotte's law, but we can approach it very nearly, as we are about to show.

Suppose the atmosphere of the mine to be at 20° C., and the water we find there to be at 18° C. If we assume that the temperature of the air, during expansion, is to remain between that of melting ice and that of the atmosphere—as, for example, at 8·8°—every kilogramme of water will deliver to the air $18 - 8{\cdot}8 = 9{\cdot}20$ thermal units.

Expansion will proceed, according to Mariotte's law, only from the moment when the temperature shall have descended to 8·8°, which corresponds to a tension of seven atmospheres. The work realized in this case will be 20,801 kilogrammetres, and the quantity of heat to be introduced into the cylinder would amount to $\frac{20801}{424} = 49{\cdot}05$ thermal units, had not the air been cooled from 20° to 8·8°, thus losing $1{\cdot}199 \times 0{\cdot}168\,(20 - 8{\cdot}8°) = 2{\cdot}26$ thermal units. The heat to be expended is, therefore, $49{\cdot}05 - 2{\cdot}26 = 46{\cdot}79$ thermal units; and the water, at 18°, to be injected into the cylinder amounts to $\frac{46{\cdot}79}{9{\cdot}20} = 5{\cdot}086$ k^s.

After having made our calculations for a tension of five atmospheres, similar to those which we have just given, we prepared the

following table, in order to compare its results with those which we obtained for eight atmospheres of tension:

	Tensions.	
	8 Atmos.	5 Atmos.
A cubic metre of air, taken from the atmosphere, requires, in order to be compressed and introduced into the reservoir, the heat of compression not to exceed 39°, atmospheric pressure having been subtracted, . . .	21711 k^m	17538 k^m
Number of thermal units to be absorbed, ...	49·73 calor's.	37·53 calor's.
Quantity of water, at 15°, to be injected into the compressor, . . .	2·062 k^g	1·564 k^g
The same cubic metre of air, after having been compressed and returned at 20° C. in the reservoir, may yield, if the temperature does not descend below 8·80° (the work necessary to overcome the atmospheric pressure having been deducted), ...	20801 k^m	16231 k^m
Number of thermal units to be introduced to the air during expansion, .	46·79	36·02
Quantity of water, at 18°, to be injected into the cylinder, . . .	5·086 k^g	3·915 k^g
If we assume that 30 per cent. of the power of which we have to dispose is lost on passive resistances and dead spaces, there remain, as utilizable work, ...	14561 k^m	11362 k^m
Ratio of utilizable work to that spent in compression, or the useful effect, .	0·641	0·647
Utilizable work produced in a second, corresponds to	194 h. p.	151 h. p.
Consumption of water by expansion, per 75 k^m, or per useful horse-power, .	0·026 k^g	0·026 k^g

As compared with the useful work, the amount of water necessary to heat the air during expansion is therefore not greater for 8 atmospheres of initial tension than for 5. The ratio of the work utilizable to that expended in compression is also supposed to be the same in both cases. These points are very important in a practical point of view; for, if it be indifferent, on the score both of water-supply and useful effect, whether we compress to 8 or to 5 atmospheres, it is not so when we take into account the first cost of the compressor, the

pipes and the machines using the air in the mines. In fact, in a given pipe the resistance which the air encounters in its motion is proportional to the square of the velocity and consequently to the square of the volume which circulates through it in a unit of time, whatever be the tension. Now, one cubic metre of atmospheric air, when compressed to eight atmospheres, occupies a volume equal to $\frac{1000}{8} = 0{\cdot}125$ cubic metre, and can deliver in the mine 14,561 kilogrammetres of useful work, an expenditure per metric horse-power of $\frac{0{\cdot}125}{194} = 0{\cdot}000644$ cubic metre.

But if compression be carried to five atmospheres the volume occupied by the air is 0·200 cubic metre; the useful work 11,862 kilogrammetres, and the volume of compressed air corresponding to a horse-power, $\frac{0{\cdot}200}{151} = 0{\cdot}001324$ cubic metre.

If we represent by R and R' the resistances which compressed air at 8 and 5 atmospheres respectively would encounter in a pipe, we have the following proportion:

$$R : \overline{0{\cdot}000644}^2 :: R' : \overline{0{\cdot}001324}^2,$$

whence
$$R = \frac{(\overline{0{\cdot}000644}^2)\,R'}{\overline{0{\cdot}001324}^2} = 0{\cdot}251\,R';$$

and
$$R' = \frac{(\overline{0{\cdot}001324}^2)\,R}{\overline{0{\cdot}000644}^2} = 3{\cdot}983\,R.$$

That is: the frictional resistance of air in the same pipe will, for the same quantity of work delivered by it, be about four times greater for 5 atmospheres than for 8.

The use of air at a high tension, when the machine which utilizes it as a motive power is at a great depth below the level of the compressor, also presents an advantage due to the effort which the air in the vertical part of the pipe exerts in virtue of its weight. This effort which assists the motion of the air in the pipes may be calculated in the following manner:

Let H = the difference of level between the compressor and the machine which utilizes the air; 1·199 = the weight in kilogrammes of a cubic metre of air at atmospheric pressure and at a tempera-

ture of 20° C; 13,500 kilogrammes = the weight of a cubic metre of mercury; T = the tension of the compressed air in atmospheres; H' = the height of the column of mercury, by which the column of air can be equilibrated without taking into account the atmosphere.

We will have: $1{\cdot}199\,H\,T = 13500\,H'$,

whence $$H' = \frac{1{\cdot}199\,H\,T}{13500}.$$

If we make $H = 500$ metres, we find:

For a tension of 8 atm., . . $H' = 0{\cdot}355$ metre,
" " " " 5 " . . $H' = 0{\cdot}222$ "

Difference, . . $0{\cdot}133$ metre.

That is to say, the resistance encountered by the air in the pipe will, for a tension of 8 atmospheres, be less by 133 millimetres of mercury, or by 0·175 atmosphere, than what it would be for 5 atmospheres.

The use of air at high pressure allows also the first cost of the compressor and the machine in which the air is utilized, to be greatly reduced. Indeed, let us suppose two machines at the bottom of a mine, doing quantities of work precisely equal; let them be supplied with air brought for the one at a tension of eight atmospheres, and for the other at a tension of 5, the air in both cases being restored to atmospheric pressure in the cylinders.

The volumes of these cylinders will be inversely proportional to the quantities of work obtainable from one cubic metre of air taken from the atmosphere, and compressed to 5 and 8 atmospheres respectively.

Let V = the volume displaced by the piston of the machine, working at the initial tension of 8 atmospheres.

Let V' = the volume displaced by the piston of the machine, working at 5 atmospheres.

We shall have: $V : V' :: 11362 : 14651$;

whence $$V = \frac{11362\,V'}{14651} = 0{\cdot}775\,V',$$

and $$V' = \frac{14651\,V}{11362} = 1{\cdot}290\,V,$$

that is the volumes of the two cylinders will be in the ratio of 1 : 1·290.

The same ratio will evidently exist between the volumes of the compressors.

§ 3. In order to determine the amount of this work, and properly to bring forward the importance, in a practical point of view, of the method of cooling and heating the air during compression and expansion, we have prepared the following table, in which we compare the results of four instalments of compressed air: two working at tensions of 8 and 5 atmospheres, respectively, without the employment of any device for cooling or heating, and consequently without expansion, and two at the same tensions, but with the application of these methods. In the four cases supposed, the useful work to be done in the mine, is equivalent to 40 horse-power, or 3000 kilogrammetres per second.

COMPARISON OF DIMENSIONS.

TENSIONS.	Without the application of cold or heat.		Cooling during compression and heating during expansion.	
	8 Atm.	5 Atm.	8 Atm.	5 Atm.
Utilizable work receivable in the mine, .	3000 k^{m}.	3000 k^{m}.	3000 k^{m}.	3000 k^{m}.
Losses on account of passive resistances and dead spaces, . . .	900 "	900 "	900 "	900 "
Actual work to be done by the air, . .	3900 "	3900 "	3900 "	3900 "
The work obtainable from a cubic metre of air when first compressed and restored to the temperature of the surrounding atmosphere,	9042 "	8267 "	2080 "	16231 "
Volume of atmospheric air to be compressed per second, . . .	0·431 m^{3}.	0·484 m^{3}.	0·187 m^{3}.	0·240 m^{3}.
If the velocity of the compressor-piston be 1·20 m. per second, its diameter will be, . .	0·676 m.	0·717 m.	0·485 m.	0·505 m.
The work necessary to compress a cubic metre of air taken at atm. pressure, . . .	29518 k^{m}.	21209 k^{m}.	22711 k^{m}.	17538 k^{m}.
Work expended per second in the compression,	12722 "	10265 "	4247 "	4209 "
Practical power of the compressor, . .	196·6 h. p.	138·8 h. p.	56·6 h. p.	56·1 h. p.

If the mean velocity of the piston of the machine, which utilizes the air, be 1·5 m. per second, its diameter will be, .	0·214 m.	0·287 m.	0·398 m	0·452 m.
The volume of compressed air delivered by the pipe in a second, . .	m^3. 0·053870	m^3. 0·096800	m^3. 0·023375	m^3. 0·048000
The diameters of the pipes for which the resistances may be zero,	0·108 m.	0·152 m.	0·077 m.	0·115 m.

The diameters of the pipes as we have just given them, have been calculated by supposing the length of each to be 1500 metres and the machine using the air to be situated 500 metres below the level of the compressors. From the experiments made at Mount Cenis, the loss of pressure due to friction in the pipes was found to be directly as their lengths, directly as the square of the velocities and inversely as the square of the diameters. It has been found that the loss is 62 millimetres of mercury for a pipe whose diameter is 0·10 m., and whose length is 1000 metres, the air circulating through it with a velocity of 3 metres per second.

Let D be the diameter of the pipe, its length 1500 metres, M the volume of air, which is to pass per second:

V = the velocity of the air = $\frac{M}{0{\cdot}785\,D^2}$; R = the resistance opposed by friction to the motion of the air. It is measured in millimetres of mercury.

We shall have: $R = \frac{62 \times 1500 \times 0{\cdot}10\,v^2}{1000 \times 3^2 \times D} = \frac{1{\cdot}0333\,v^2}{D}$.

Replacing v by $\frac{M}{0{\cdot}785\,D^2}$, we find for the expression of the value of the diameter, $D = \sqrt[5]{\frac{1{\cdot}6768\ M^2}{R}}$.

Let us assume that R cannot exceed 335 millimetres of mercury in the two columns at eight atmospheres, nor 222 millimetres in the two at five atmospheres.

As we have seen above, these values represent the effort due to the weight of the air and is that which comes to its assistance in its motion. If we replace R by these values in the formula given above, the value of D will be such that there will be no resistance to the

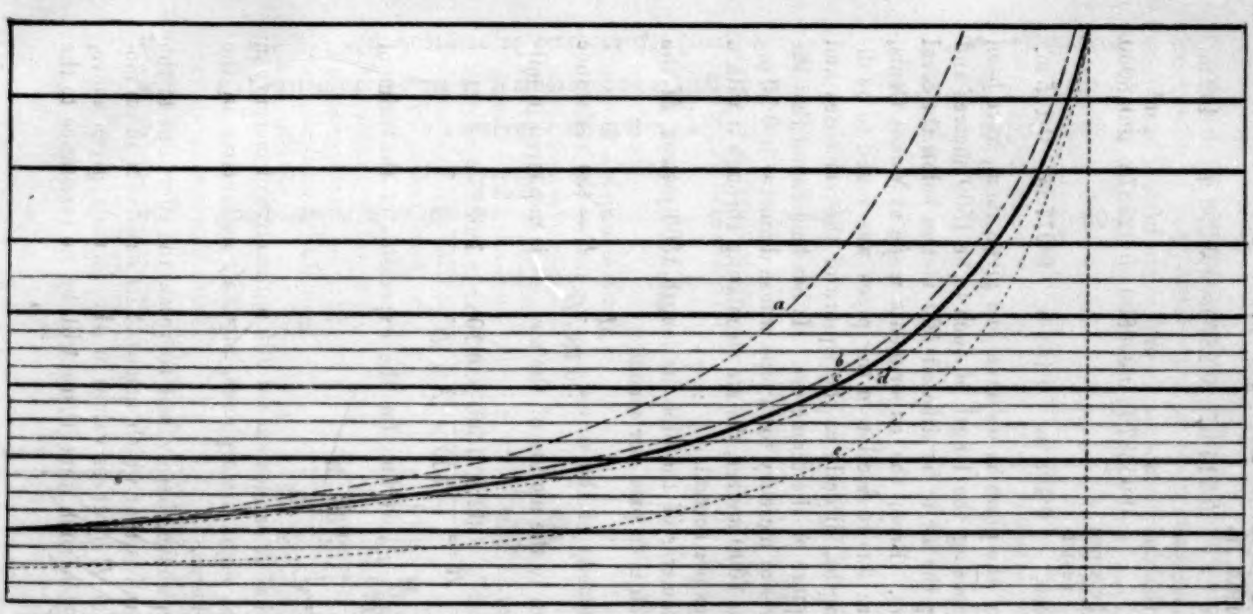


Fig. 2. A diagram indicating the variations of pressure in a cylinder 1 *metre long, where the air is carried to* 8 *atmospheres and then allowed to expand.*

a,	Compression with increase of temperature of the air from	+ 20° to + 263·67°.
b,	" " temperature varying from	+ 20° to + 39°.
c,	" at the constant temperature of	+ 20°. Mariotte's law.
d,	Expansion of the air with temperature varying from	+ 20° to + 8·80°.
e,	" with a decrease of temperature from	+ 20° to — 148·20°.

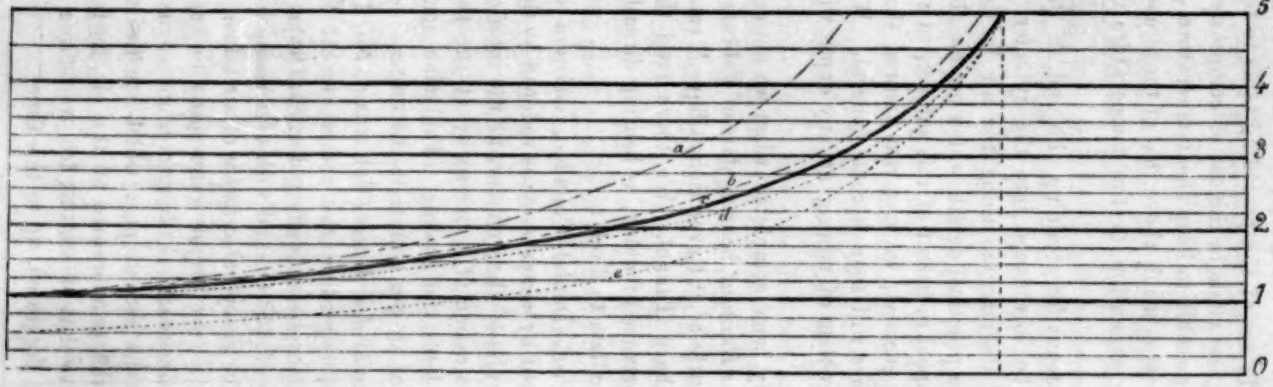


Fig. 3. *A diagram indicating the variations of pressure in a cylinder* 1 *metre long, where the air is carried to* 5 *atmospheres and then allowed to expand.*

a,	Compression with increase of temperature of air from	+ 20° to + 159·30°.
b,	" " temperature varying from	+ 20° to + 39°.
c,	" " a constant temperature of	+ 20°. Mariotte's law.
d,	Expansion of the air at temperature varying from	+ 20° to + 8·80°.
e,	" with decrease of temperature from	+ 20° to — 148·20°.

movement of the air, in the pipes. We thus find for the diameters of the pipes 0·108 metre, 0·152 m., 0·077 m., and 0·115 m.

It is sufficient to compare the figures of the preceding table to see how important would be the progress made in the use of compressed air in mining operations, were it possible to keep the temperature of the air from rising during compression much above that of the atmosphere, and from falling during expansion to the temperature of freezing water.

We think we have found the means for attaining this end, in the use of water-spray, which could be introduced into the cylinder of the compressor, and into that of the machine using the air in the mine. We have not indicated the practical details which permit the realization of our plan, but we appeal in behalf of this subject, to all constructing engineers. If they succeed, we may rest assured that the use of compressed air in mines will soon become general. We can likewise predict that the problem of mining at any depth will be solved.

N. B.—This paper had scarcely been completed when we noticed in a journal published at Mons, *Le Hainaut*, bearing date of February 19th, 1875, an article under the title of "Revue Scientifique," relative to the boring of the St. Gothard Tunnel. We there read the following passage, upon the importance of which, as bearing directly upon the subject in hand, it is needless to dwell:

"The compressor is that of Prof. Daniel Colladon, assistant to the contractor. The heat produced by compression is reduced by the circulation of cold water in the walls of the cylinder, in the interior of the piston and its rod; an injection of water-spray at the two extremities of the cylinder completes the cooling. The mine compressors furnish 15 cubic metres of air per minute in the tunnel."

We find in the *Revue Universelle des Mines* (Vol. xxxvi, No. 1), some details, due to M. Habets, regarding the compressor of M. Colladon. Compression to six atmospheres is effected at St. Gothard without exceeding a temperature of 35° C., and with a consumption of only 1 litre of injected water for every cubic metre of air taken.

The first part of our plan, *i. e.*, the use of water-spray to keep down the temperature during compression, is, therefore, not as new as we at first supposed. As to the second part, which consists in using the same means to keep the temperature of the air, during complete expansion, from falling to that of melting ice, we believe it has never been practiced, or even suggested, up to this time.

THE NATURAL SCIENCES IN COMMON SCHOOLS.

[Abstract of a paper read by Prof. JACOB ENNIS, at a Meeting of the Franklin Institute.]

Every day when the last half-hour of the schooltime arrives, the pupils should take their seats closely in front of the teacher's table. Then the teacher should perform some scientific experiment, or exhibit some object of natural history, and tell all that can well be told about it. That is, he, or she, should every day deliver a conversational lecture half-an-hour long, and practically illustrated by some exhibition in science. When taught in this way, the natural sciences are more easy to be learned than arithmetic or grammar. It is as easy to understand that oxygen and hydrogen unite to form water, as that two and two make four; and the delight to the child in seeing water composed in this way, is greater, beyond all comparison, than to see that two and two make four. What can be easier than to learn that the common salt which we daily eat is composed of a metal (sodium), and a beautiful greenish-yellow gas (chlorine). As all the words of a book are composed of only twenty-six letters, so every child can understand that all the various substances on our globe are composed of sixty-three simple elements. The great science of chemistry is nothing more than to have a knowledge of these sixty-three elements, and how they are united to form compounds, and what are the natures of these compounds. The first step for the learner is to see these simple elements, to handle them, to experiment with them, and to understand their chief characteristics. This lets the child at once into the great secrets of the universe, as clear as day, and he is delighted.

All the other physical sciences can be made as simple and easy as chemistry; and when all are harmoniously united, what a world of wonder do they open before the astonished view of the youthful mind. It is quite enough for the young student to learn the *general principles* of these sciences, copiously illustrated by facts. They are the most valuable parts of a science, for they give a bird's-eye view of an entire science, and the methods of working in that science. These general principles are also the most delightful portions. On this account it is that in an ordinary course of education, say until the child is 15 or 16 years old, all the natural sciences should be intro-

duced. Then the child imbibes and enjoys the very cream of them all. He is delighted, because he is every day seeing and hearing something new. What he learns with delight, he remembers long. Indelible ideas and impressions are then produced. He may very properly omit the *minutiæ* of the sciences, the difficult and the puzzlesome parts, parts which may be learned from books in maturer years; for it is a wonderful fact, which may well fill us all with amazement at the wide extent of creation, that all the sciences are so very extensive, that no scientific man is perfect in any one. No astronomer knows all the facts in astronomy, no chemist is familiar with all the facts in chemistry, no botanist knows all the plants, no zoologist knows all the animals. Therefore, the mouth of the objector is stopped. If a child is not to study the sciences because he cannot learn everything they contain, then no one should study them at all.

Delight the pupils during the last half-hour every day with the wonderful exhibitions and the wonderful truths of the sciences, and those pupils will make more rapid progress in all their present primary studies. Instead of being a hindrance to the other branches, the sciences must be a help. If the child's progress is now slow, it is not for want of time, but for want of interest in his school. Awaken an interest, and he will go forward. The natural sciences are the very things to arouse attention, to inspire life and animation. I do not wonder that, in general, children find their schooling process very irksome and distasteful. There is but little to relieve the confinement and restraint. Geography, for instance, is studied from the time a child is 8 until he is 16 years old; that is, during eight long and weary years. No wonder that during this long space of time, geography grows stale and insipid. The same may be said of grammar, and all the present primary studies. And yet the objectors to the sciences complain that the boys and girls, on leaving school, are still generally deficient in their primary studies. I am told that, on entering the Boys' High School or the Girls' Normal School, the new pupils are found so very deficient in arithmetic and grammar, as to require much additional time in those institutions to bring them up to the proper standard. And so things will continue as long as the present system lasts. It has been tried long enough and found wanting. But introduce the natural sciences, and all will be animation and encouragement. New life and new progress will

be infused into all the other studies. The enjoyment of the scientific exhibitions and the conversational lectures, is like their dessert after dinner. It is not only the most delightful, but the most profitable part of the exercises of the day, for the pupils learn more in that last half-hour than during any hour and a-half before. All this is not theory nor conjecture. It has been my daily observation during many years.

The proportion of female to the male teachers in our public schools, is as 30 to 1. Every year, hereafter, 250 young ladies are to graduate from the Girls' Normal School, with teachers' certificates. In that institution the ancient and the modern languages are not taught, and the mathematics are pursued only to a moderate extent; therefore, an abundance of time is left for the study of all the natural sciences, so that those new teachers may bring all these sciences, experimentally and practically, in our public schools.

It was a great benefit to Baltimore when the late Mr. Hopkins gave $3,500,000 to found a university in that city, but it would be a greater benefit to Philadelphia if all the natural sciences were taught, experimentally, every day in all our public schools.

The Maiche Battery.—The inventor states that when his platinized carbon battery is charged with water acidulated with 10 per cent. of sulphuric acid, a zinc surface of 25 square centimetres is sufficient for the production of electric light. The electromotive force is, however, only about two-thirds as great as Bunsen's. By charging with bichromate of potash, he makes his battery the most intense of all, for the two forces are combined, and it possesses an electromotive force superior to that of the bichromate, while furnishing a double quantity of electricity. His battery has, therefore, the advantage of either being charged with simple acidulated water, or with the addition of the bichromate which makes it the most powerful known electro-generator.—*Les Mondes*, March 15. C.

Decomposition of Barium Dentoxide, at low Temperatures.—Gay-Lussac anticipated that in a vacuum, dentoxide of barium would be decomposed at a much lower temperature than at the ordinary atmospheric pressure. M. Boussingault finds that a complete decomposition is effected at a dull red heat.—*Acad. des Sciences*, March 19. C.

UNDERGROUND TELEGRAPHS IN FRANCE.

[From *Engineering*, London, May 4th, 1877.]

As might be assumed, the mileage of underground wires laid down in the city of Paris is very much below that over which London foot-passengers tread as they traverse the streets of our metropolis. Nevertheless Mr. Aylmer's paper on "Underground Telegraphs in France," recently read before the Society of Telegraph Engineers, possesses many features of interest, and some points which it may be worth noticing.

The earliest attempts made in France to establish underground telegraphs consisted of merely burying copper wires covered with india rubber. Then followed wires covered with gutta percha treated in a similar manner. In both cases the wires were simply laid in the bottom of the trench provided for their reception, and thus wholly destitute of protection, their speedy failure was, as happened, only to be expected. Towards 1852 a plan was tried of drawing the insulated wire into a lead pipe of as nearly as possible its own diameter. Failure again ensued, by reason of the infiltration of street gas at the joints in the lead pipe. Moreover, the percha covering of the wire frequently became so torn in the operation of drawing it into the pipe as to establish contact between the conductor and the lead coating. Some years later another method was tried. It had been observed that some naked wires which had been imbedded in asphalt some ten years previously, retained their insulation. A trench, some 5 ft. deep, was accordingly dug, a layer of fine sand was laid in it, and iron wires of No. 8 B. W. G. (chosen in preference to copper wire on account of its being less susceptible of variation from changes of temperature) stretched in the trench in sets of 4, 6, or 10, and in sections of 90 yards in length, being held at a uniform distance from each other by means of specially constructed guides which could be removed after the asphalt had been applied. A hot compound, composed of 60 parts of asphalt, 7 of bitumen, and 33 of fine washed gravel, was then poured into the trench so as to completely envelop the wires. For a few years the result was in every way satisfactory, but ultimately loss of insulation, and finally contacts, became frequent. Movements of the soil cracked the insulating compound,

which, moreover, lost its qualities and became soft where exposed to the action of escaped gases from the gas mains. The cost of this method was about 40*l.* per mile per wire.

In 1858 attempts were made to employ lead pipes. Five or more gutta percha covered wires, first covered singly with tarred hemp, and then when twisted up into a cable again wound round with tape, were drawn into a lead pipe, which was laid into a trench and covered up. Mechanical injury and bad joints in the leaden pipe soon caused its abandonment.

So far Mr. Aylmer merely relates France's early efforts in the direction of underground wires—all of which were attended, more or less, with failure. We now come to the system at present in use, and which may be regarded as successful, from the fact of its having already stood the test of twelve years' work. And here it may be well to note that the underground telegraphs in France, as carried out at the present date, come under two distinct and different conditions, viz., that in which the wires follow the route of, and are laid in, the street sewers of Paris, and that in which they are laid underground in trenches in the ordinary way.

Paris, as is generally known, possesses a very complete system of sewers. They are not what may be regarded as merely large drains, but are veritable subways, in any of which a man may freely move about. The main sewers are broad and lofty tunnels, with footways on either side—the sewage flowing at a low level in the centre. They are kept scrupulously clean, and frequent manholes, opening into the foot pavement above, give means of access, light and ventilation. As may be imagined, Parisian engineers have not been slow to recognize the advantages which such a system of subways presents for laying telegraph wires, pneumatic tubes, water and gas mains.

Whether the wires are to be laid along the sewage system or underground, up to a certain point they are subject to the same system of preparation. Gutta percha wires, such as are used in England, are made up into cables, protected by a serving of stout, tarred, hemp strand, which has again a covering of strong tape, also tarred. Before being tarred, both the hemp and the tape are steeped in a solution of sulphate of copper. Only the best Stockholm tar is used. Thus composed, the cable is fit for laying in pipes underground, but when required for use in a sewer, it is drawn into a lead pipe in size as nearly as possible that of the cable. Before being drawn into the

pipe, the cable is rubbed with talc to reduce friction. Finally the lead pipe is passed through a wooden die, which causes the lead tube to adapt itself to the cable within it. Lengths of about 100 yards are thus prepared and joined up before being placed in position. The tubing is usually ·05 of an inch thick, and the joints are made in the following manner: The core is first joined through, and this done, the wires are tightly wound round with a band of stout vulcanized rubber. Strong yarn is passed round this and tarred canvas over it, which is also bound with yarn. A piece of lead piping, previously slipped on, is now brought over the joint, and its ends pinched tightly round the cable tube. The whole is then finally wrapped with tarred canvas, well bound with galvanized iron wire. The result is said to be a very compact joint, formed without the intervention of heat. When all complete the cable is lifted into its place, usually specially prepared brackets, capable of holding two or more cables, fixed to the walls of the sewer.

The treatment of underground wires is somewhat similar, except in the make-up of the cable, to that pursued by our own telegraph engineers. The cables are drawn into pipes from 2 in. to 4 in. in diameter, in lengths of from 200 to 400 yards. Special and carefully devised apparatus is employed for drawing in the cable. There is, however, this difference between the French and our own system—slip pipes are used at specified distances in the place of what are known with us as "flush-boxes"—that is, boxes, the lids of which are laid level with the street pavement, by means of which access may be readily had to the wires within. The French system of slip pipes involves the opening of the street at the point where it is used, which in this sense, is disadvantageous.

The electrical condition of the Paris wires is spoken of as being higher, as a rule, than that required by the French Telegraph Administration, viz., 675 megohms per statute mile, at 20 degrees Centigrade.

Lines constructed upon these two principles have been in use over 12 years; none of them have broken down or shown signs of decay. Within the city of Paris there are 119 miles of underground line, of which 39 miles are laid in buried iron pipes, and 80 miles are in lead tubing laid in the sewers. The total length of wire is 2561 miles. In the chief provincial towns in France there are about 100 miles of similar lines at work.

CHICAGO PUMPING ENGINES.

The test of the pumping engines lately constructed for the West Side Pumping Station of the city of Chicago, Ill., by the Quintard Iron Works of New York, was commenced in the month of January last, but in consequence of the condition of the boilers, from the presence of scale and mud, extreme cold weather and injudicious firing, the engines failed in the required duty of 90,000,000 ft. lbs., although they discharged more than the required volume of water, of 30,000,000 U. S. gallons in 24 hours.

The Commissioners upon this occasion were: Moses Lane, of Chicago; Chas. H. Haswell, of New York; Henry Warrington, of Chicago; Chas. Hermany, of Louisville; and T. J. Whitman, of St. Louis.

The boilers having been cleaned, and more reliable means effected of measuring both the flow of the water delivered and the height to which it was raised, than upon the previous occasion, the test was renewed on the 18th of April, under the direction of Messrs. Lane, Haswell and Warrington, and continued for 48 hours with each engine, with the following results:

	ENGINES. No. 25.	No. 26.
Period of operation,	48 hours.	48 hours.
Pressure of steam at boiler,	61·77 lbs.	60·86 lbs.
Pressure of steam at engine,	59·25 lbs.	60·25 lbs.
Point of cutting off,	30 to 33 in.	30 to 33 in.
Revolutions,	11·177 per min.	10·63 per min.
Temp. of feed water,	124° 4′.	131°.
" external air	45° 9′.	60° 48′.
" engine room,	75°.	77° 94′.
" fire room,	77°.	73°.
Coal consumed (Lackawanna broken lump),	42,400 lbs.	43,028 lbs.
Av. height of water in standing pipe,	155·83 ft.	159·11 ft.
Av. height of water as indicated by pressure-gauge at delivery,	157·06 ft.	159·34 ft.
Feed water per hour,	9779·5 lbs.	10059·4 lbs.
Width of weir,	7·94 ft.	7·94 ft.
Av. height of weir,	·9787 ft.	·9543 ft.
Volume of leak in weir-box or flume,	5768 cu. ft.	5768 cu. ft.

The volume of water discharged, computed by Francis's formula, and the duty developed for each engine, were as follows:

VOLUME.

$$Q = 3{\cdot}33 \times {\cdot}9787^{\frac{3}{2}}(7{\cdot}94 - \overline{2 \times {\cdot}9787}) \times 172800 = 4314617{\cdot}28 \text{ cu. ft.}$$

Leakage of weir-box and gate, ... 5768· " "

4320385·28 cu. ft.

In 48 hours = 16159363 gallons in 24 hours.

DUTY.

$$\text{Hence, } \frac{4320385{\cdot}28 \times 62{\cdot}4 \times 155{\cdot}83}{\frac{42400}{100}} = 99066718{\cdot}27 \text{ lbs. of water}$$

raised 1 ft. in height, with 100 lbs. of coal.

The engines are vertical compound, with over-head beam.

PRINCIPAL DIMENSIONS.

High-pressure cylinder, diameter 48 in.
Stroke of piston, 6 ft.
Low-pressure cylinder, diameter 76 in.
Stroke of piston, 10 ft.
Pump, 51 in.
Stroke of piston, 10 ft.
Fly-wheels, each 32 ft. in diameter and 60 tons in weight.
Beam, 36 ft. in length and 7 ft. in depth.
Boilers, 4 cylindrical, fire tubular return.
Diameter of shell, 6 ft. 6 in.
Length, 16 ft.
Tubes, 100 of 4 in. in diameter and 16 ft. in length.
Drum, 3 ft. 6 in. diameter and 8 ft. in height.
Grate surface, 116 sq. ft.
Average consumption of coal per hour, 890 lbs.
Average evaporation per pound of coal, 11·12 lbs.

Fire-proof Paper.—Asbestos is found in large quantities in the valley of Aosta, in the Italian Alps. A priest of Arezzo, named Victoria del Corana, has experimented with it in the paper mills of Tivoli, and is now making a fire-proof fabric at a cost of four francs per kilogramme. The most useful application which has yet been made of the paper, is for the decorations of theatres.—*Papier-Zeitung*, April 19. C.

ON THE TEMPERATURE OF COMBUSTION.

By M. BERTHOLLET.

[Translated from the *Comptes Rendus* of March 5th, 1877, for the JOURNAL OF THE FRANKLIN INSTITUTE, by Chief Engineer ISHERWOOD, U. S. Navy.]

1st. The temperature of combustion of a gaseous mixture is, as all know, the excess of temperature which will be acquired by the gaseous products of combustion if they preserve the totality of the heat disengaged in the reaction. Q being that quantity of heat and C the specific heat in weight of the products, we have $t = \frac{Q}{C}$, a formula which applies equally when the two gases burn in equivalent proportions, and when they are mixed with incombustible gases. In most cases, as M. H. Sainte-Claire Deville has shown, only a portion of the combustible gases enter into reaction; another portion remains in presence of a corresponding quantity of oxygen, because the temperature developed is high enough to determine the partial decomposition of the combination (dissociation). Let k be that combined fraction and C_1 the mean specific heat (between zero and t) of the system, such as exists at the moment of the combustion, we shall have, in general,

$$t = k\frac{Q}{C_1}. \quad . \quad . \quad . \quad (1)$$

Q is a constant which depends solely on the initial temperature, which is here supposed to be zero; but t, k and C_1 are three variables connected by equation (1).

2d. We can find a second relation between these three variables by adopting the experiments of M. Bunsen (*Ann. Pogg.*, 1867). The idea of this illustrious physicist was to burn the combustible mixture at constant volume and to measure the pressure P developed at the moment of combustion. Thus, calling g the theoretical condensation, that is the proportion of the volume of the gases produced in a total reaction after cooling, to the volume of the primitive gases, we have the relation:

$$P = P_0(1 - k + kg)(1 + at). \quad . \quad (2)$$

Let a still be the mean specific heat at constant volume of the component gases, and b that of the composite gas, we have,

$$C_1 = (1-k)\,a + k\,b, \quad . \quad . \quad . \quad (3)$$

$$t = \frac{k\,Q}{(1-k)\,a + k\,b'} \quad . \quad . \quad (4)$$

$$\frac{P}{P_0} = (1-k+k\,g)\left[1 + \frac{a\,k\,Q}{(1-k)\,a + k\,b}\right]. \quad . \quad (5)$$

As we have for the three unknowns t, k, and C_1 connected by equation (1), substituted five connected by the three equations (3), (4), and (5), the problem remains indeterminate.

3d. M. Bunsen endeavored to resolve it by two hypotheses, namely, that the specific heat a of the component gases, and that of their products b, are constant quantities independent of the temperature and pressure. Thence k and t will be given by two equations of the second degree. The following table contains a summary of the results of M. Bunsen, whose permission to transcribe them has been obtained:

	Combustible mixture in volumes.	$\frac{P}{P_0}$ (Experiment.)	k (Calculated.)	t (Calculated.)
I	$\frac{2}{3}\,CO + \frac{1}{3}\,O$	10·78	0·351	3172°
II	ditto	10·19	0·319	2893
III	$\frac{2}{3}\,CO + \frac{1}{3}\,O + 0{\cdot}1079\,O$	9·05	0·314	2558
IV	ditto $+0{\cdot}6857\,CO$	8·89	0·460	2471
V	ditto $+0{\cdot}8554\,O$	8·44	0·478	2325
VI	ditto $+1{\cdot}0861\,O$	7·86	0·490	2117
VII	ditto $+1{\cdot}2563\,Az.$ (air)	7·73	0·515	2084
VIII	ditto ditto	7·35	0·470	1909
IX	ditto $+1{\cdot}7145\,O$	6·67	0·520	1726
X	ditto $+2{\cdot}1559\,O$	5·83	0·512	1460
XI	ditto $+3{\cdot}1629\,CO$	4·79	0·527	1146
XII	$\frac{2}{3}\,H + \frac{1}{3}\,O$	9·97	0·338	2854
XIII	ditto	9·75	0·336	2833
XIV	$\frac{2}{3}\,H + \frac{1}{3}\,O + 1{\cdot}2599\,Az.$ (air)	7·49	0·547	2024

According to these figures k, or the fraction actually combined, would increase from 0·31 to 0·53 in measure as the presence of a larger proportion of inert gas lowered more and more the temperature of the combustion; and the variation would have its maximum in the neighborhood of 2500 degrees. The discrepancy of one experiment with another amounts to 6 per centum on the measured

pressure, corresponding to a difference of one-tenth on the combined fraction and on the temperature; nevertheless M. Bunsen believed himself entitled to conclude that k remained invariable and equal to one-third between 3200 and 2500 degrees, temperatures towards which half of the explosive gas rose suddenly to preserve anew a constant value until near 1150 and lower. There is no utility in discussing this question in a more profound manner, because the fundamental hypothesis of the constancy of the specific heat of the carbonic acid is erroneous.

4th. It is only for the simple gases near the perfect state, and for carbonic oxide formed comparably of gases without condensation, that the experiments of Regnault and of Wiedemann authorize the admission of the constancy of the specific heat under constant pressure between zero and 200 degrees. No other experiments have been made on the specific heats of gases under constant volume at different temperatures. Should we admit as a hypothesis which each may value as he chooses, that these conclusions are applicable to chlorohydric gas, the only compound formed without condensation and of which the formation can be determined by direct combustion, the specific heat of this gas being likewise reputed equal to that of its elements,[1] then, the equations of the first degree,

$$t = k\frac{Q}{C}, \text{ and } P = P_0\left(1 + a\,k\frac{Q}{C}\right),$$

permit the calculation of t and k, that is to say the dissociation, by the analogous experiments of M. Bunsen.

5th. But none of these hypotheses, and consequently none of these calculations, are authorized by experiment for the gases formed with condensation, such as carbonic acid; in fact, the specific heat of such gases vary, and very rapidly, with the temperature. In connecting the specific heat under constant pressure with the molecular weight (which occupies 22·32 *l.* at zero and 0·76 metre), we find for the mean values of that quantity between zero and 200 degrees:

For $C^2\,O^4$	$= 44$ gr. : $C =$	$8{\cdot}41 + 0{\cdot}0053\,t.$	(Mean of Regnault and Wiedemann).
" $A\,z^2\,O^2$	$= 44$ " : $C =$	$8{\cdot}96 + 0{\cdot}0028\,t.$	Ditto.
" $C^2\,S^4$ gas	$= 76$ " : $C =$	$10{\cdot}62 + 0{\cdot}007\,t.$	Regnault.
" $A\,z\,H^3$	$= 17$ " : $C =$	$8{\cdot}51 + 0{\cdot}00265\,t.$	Wiedemann.
" $C^4\,H^4$	$= 28$ " : $C =$	$9{\cdot}42 + 0{\cdot}0115\,t.$	Ditto.

[1] We know this last supposition to be not quite true, chlorine having a specific heat a little above that of the other simple gases under the same condition.

The condensation is $\frac{2}{3}$ for the first three gases; and $\frac{2}{4}$ and $\frac{2}{5}$ for the two others. It cannot be doubted that vapor of water would offer analogous variations.

The specific heats at constant volume have not been determined for different temperatures, but we know that their approximate value can be obtained for the gases which follow the laws of Mariotte and Gay-Lussac by considering the difference of the two specific heats as equivalent to the exterior work of dilatation, that is to say, as represented by 1·93. We should thence have the mean value:

$$\text{For } C^2\,O^4,\ C' = 6{\cdot}48 + 0{\cdot}0053\,t.$$

But it is more than doubtful if that value is applicable under pressures approaching 10 atmospheres.

6th. Let us calculate the combustion temperature of carbonic oxide with oxygen taken in equivalent volumes. According to this new data, and admitting $Q = 69000$, we would have

$t = \frac{69000}{8{\cdot}41 + 0{\cdot}0053\,t} = 2900°$ about, at constant pressure; and $t = 3060°$ about, at constant volume; temperatures greatly lower than the 7200° and 8300° to which we are led by the hypothesis of constant specific heats. According to the above empirical formula, $C = 54{\cdot}3$ between zero and 3000°, which is a little more than double the value of the specific heat of the elements supposed to be gaseous. This, however, according to analogies, is not at all impossible; indeed, it exists for the chlorides of phosphorus and of gaseous arsenic. At constant volume calculation gives $C = 22{\cdot}4$.

We must hasten to add that the empirical formula representing the specific heat of the carbonic gas only between zero and 200°, could be extended to 3000° as merely a hypothesis to render evident the erroneousness of old valuations. We can also show in other ways that the values deduced are too great for application to the totality of the combustible gas: in fact there results from it a pressure about one-fifth less than the figures found by M. Bunsen; but the admission of a partial dissociation is sufficient to render the pressures and temperatures compatible with the specific heat derived from the formula.

7th. Nevertheless, the measures of M. Bunsen remain very valuable, accepting them as exact, because they enable a calculation to be made of the two limits between which the temperature of combustion is necessarily comprised, and that without any hypothesis as

regards specific heat; nothing more is required for the calculation than an admission of the generality of the laws of Mariotte and Gay-Lussac. From equation (2) we draw in fact:

$$t = \left(\frac{P}{P_0}\,\frac{1}{1-k+kg} - 1\right) 273. \qquad (6)$$

It is clear that the combined fraction at the moment of explosion, is comprised between zero and 1 for a mixture formed in equivalent proportions; and between zero and m for a mixture containing $1-m$ volumes of inert gas; whence in replacing k successively by zero and 1, or by zero and m, we shall obtain the two limits sought. These limits will be found in following table:

			$\frac{P}{P_0}$	t_1	t_2
I	$\frac{2}{3}\,CO + \frac{1}{3}\,O$		10·78	4140°	2612
II	ditto		10·19	3900	2537
III	ditto	+ 0·1079 O	9·05	3066	2198
IV	ditto	+ 0·6857 O	8·89	2760	2154
V	ditto	+ 0·8554 O	8·44	2537	2031
VI	ditto	+ 1·0861 O	7·86	2280	1875
VII	ditto	+ 1·2563 Az.	7·73	2203	1838
VIII	ditto	ditto	7·35	2083	1734
IX	ditto	+ 1·7145 O	6·67	1875	1548
X	ditto	+ 2·1559 O	5·83	1505	1319
XI	ditto	+ 3·1629 O	4·79	1150	1034
XII	$\frac{2}{3}\,H + \frac{1}{3}\,O$		9·97	3809	2449
XIII	ditto		9·75	3718	2389
XIV	ditto	+ 1·2599 Az.	7·49	2126	1715

The combustion temperature of carbonic oxide with oxygen, at constant volume, is there comprised between 4000° and 2600°; and, with air, between 2200° and 1750°, limits already closely restricted. That of hydrogen with oxygen between 3800° and 2400°; and, with air, between 2100° and 1700°.

These last numbers appear rather small when compared with the melting point of platinum, estimated at 2000°, but in this estimation the specific heat of platinum is supposed constant, while, in fact, it varies with the temperature. If the laws of variation deduced from the measures of Dulong be adopted, platinum should melt at about 1400°; the true temperature is probably intermediate, but it is a disputed point: beyond the limits measured by the air thermometer no temperature is known with certainty.

We would remark that, starting from the mixtures which contain their volume or more of inert gas, the difference between the temperatures calculated by Bunsen and the limit which corresponds to a total combination, does not exceed one-tenth.[1] The difference falls to 45° and even to 4° for more diluted mixtures: such would be the interval between a total combination and a combination of one-half only; an interval too near the limits of experimental error to authorize any conclusion whatever, and *a fortiori* the admission of a simple law of discontinuous numerical relations.

But if these experiments give no other certain data relative to the degree, to the nature, or even to the existence of dissociation,[11] they appear, notwithstanding, to establish the possibility of producing temperatures really approaching 3000°.

Curious Phenomenon of Heat.—M. J. Olivier reports the following experiment: A square bar of steel, about 15 millimetres thick, and 70 to 80 mm. long, is grasped firmly by the operator, one hand being placed at the centre of the bar and the other at one end. The free extremity is pressed strongly against a rapidly revolving emory wheel. In a few minutes the rubbed extremity becomes hot, the hand at the centre of the bar feels no heat, but the hand at the remote extremity becomes so hot that the operator is obliged to loosen it. C.

Coloring Canned Vegetables by Chlorophyle.—MM. A. Guillemare and F. Lecourt have experimented successfully with chlorophyle, as a substitute for the salts of copper in giving a green color to peas, beans, cucumbers, and other canned or pickled vegetables. The color thus obtained is said to be more natural than that which is given by copper, the vegetables are more wholesome, and the flavor is better on account of the absence of all astringent or metallic taste.—*Comptes Rendus*, April 9. C.

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[1] M. Bunsen admits $Q = 67300$ in place of 69000, but this change in the heat of combustion of carbonic oxide does not sensibly modify the results of the calculation.

[11] Cyanogen burnt in air at constant volume forms an exception. In fact, it is easy to prove, admitting the pressure (11 atmospheres) observed by M. Bunsen, that the product is not composed exclusively of carbonic oxide, oxygen and azote, but that it necessarily contains carbonic acid, the temperature of combustion being comprised between 2700° and 2100°.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS, DURING THE LAST TEN YEARS.[1]

By Dr. A. W. Hofmann.

From the *Chemical News*.

[Continued from Vol. ciii, page 417.]

Since 1870 the muffle-furnaces formerly employed at Stolberg have been combined with a system of plates according to the design of Hasenclever and Helbig. The system has subsequently experienced important modifications, retaining the principle for inclined plates, until a kiln for blende has been developed which has now for some years been found suitable to be retained in an unmodified form.[ii] The products of combustion, which play round the muffle, heat from below an inclined plane formed of plates and about 8 metres in length. On this inclined plane the ore slides down to a roller fixed at the lower end, and as this revolves is delivered first into the muffle, whence it is drawn down by manual labor into the lower hearth, where it is roasted until fit to be smelted for zinc. The gases escaping from the muffle, still poor in sulphurous acid, sweep over the inclined plane, become richer, and effect a preliminary roasting of the blende. Since finely granular bodies if thrown on a heap form a surface with an approximately constant angle of 33°, as the ore slides down the plane which has an inclination of 43° there would be formed at the bottom a heap of more than 1·5 metres in depth, a perfect roasting of the interior of which would be impracticable. To prevent the stratum of ore from becoming too thick, partitions are arranged, which descend to the distance of a few centimetres from the slope. In this manner a thin stratum of ore is maintained over the whole surface. Furnaces of this construction are at work at Oberhausen and Stolberg, and are in course of construction at Lethmathe, near Iserlohn, and Rosdzin, in Silesia. The consumption of fuel is the same as in the roasting kilns common at zinc works, 28 per cent. of coal to 100 raw blende; the cost of labor is 1·6 of a shilling per 100 kilos. blende.

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[1] "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

[ii] Hasenclever and Helbig, *Zeitschr. des Vereins Deutscher Ingenieure*, 1872, 705.

In Freiberg a black blende, containing iron pyrites in considerable amount, is used for the manufacture of sulphuric acid, the broken ore being submitted to a preparatory roasting in large kilns. The burnt residue is then ground and receives its final roasting in a reverberatory.

Formation of Sulphuric Acid in the Lead Chambers.—Recently, as well as in earlier years, proposals have been made to substitute some other apparatus for the chambers. Verstraet[i] employs for this purpose columns formed of earthen vessels. But his method, like earlier suggestions for preparing sulphuric acid on any other than the traditional principle, has not become of practical importance.

The chemical process during the formation of sulphuric acid in the chambers, and the reactions involved, have been latterly further explained.

Reich[ii] introduced a method of determining the sulphurous acid in the gases from the kilns and furnaces, which has met with an extensive application. He uses a solution of iodine in potassic iodide of known strength, to which a little starch has been added. By aspiration the gas is drawn through the blue liquid till decoloration is effected. If the volume of the aspired gases has been measured the percentage of sulphurous acid is known. This method of examination has the great advantage that it can be accurately executed by a common laborer (?), the solution of iodine merely being prepared in the laboratory.

The composition of kiln gases theoretically the most advantageous was first calculated by Gerstenhöfer, and was communicated to several chemical works as early as 1866. The same calculation, with a slight difference, was subsequently produced by Schwarzenberg.[iii] According to his assumption, when the chambers are working well the gaseous mixture leaving them should still contain 5 per cent. (by volume) of oxygen. Hence the normal composition of the gases entering, when sulphur is employed, must be:—

Sulphurous acid (by volume), . .	11·23
Oxygen, ...	9·77
Nitrogen, ...	79·00

[i] Verstraet, *Dingl. Pol. Journ.*, clxxix, 63. *Wagner Jahresber.*, 1865, 226.

[ii] Reich, *Berg und Huttenm. Zeitung*, 1858.

[iii] Schwarzenberg, "Bolley's Handbook der Techologie," ii, 355.

and when pyrites are in use, and the gases at their exit contain 6·4 per cent of oxygen—

Sulphurous acid, ...	8·59
Oxygen, ...	9·87
Nitrogen, ...	81·54

Since, for every 1000 grms. of sulphur used in the form of bisulphide of iron 8144·9 litres of gas (calculated at 0° temperature and at a pressure of 750 m. m. of mercury) enter the chambers, and for the same weight burnt in the free condition only 6199 litres, a given quantity of sulphur burnt as bisulphide of iron, yields—

$$\frac{8144{\cdot}9}{6199} = 1{\cdot}314$$

times as much gas as if it had been burnt in the free condition.

The number given above represents the proportion of the bulk of the lead chambers, which, for an equal production of sulphuric acid, is necessarily larger for roasting pyrites than when free sulphur is burnt. Gerstenhöfer, for the escaping gases both in roasting pyrites and in burning sulphur, employs a normal amount of 6 per cent. by volume of oxygen. Hence the most advantageous composition of the gases on entering, theoretically speaking, in case of sulphur is:—

Sulphurous acid, . . .	10·65	by volume,
Oxygen, ...	10·35	"
Nitrogen, ...	79·00	"

For pyrites:—

Sulphurous acid, . . .	8·80	"
Oxygen, ...	9·60	"
Nitrogen, ...	81·60	"

The statements as to the proportion of oxygen in the gases leaving the chamber, vary widely. According to R. Wagner[1] the escaping gases do not contain more than 2 to 3 per cent. of oxygen. Scheurer-Kestner, in a private communication to A. W. Hofmann, mentions that the gases escaping from the chambers contain 6 per cent. of oxygen, independent of the oxygen present in the form of nitrous acids. The varying statements may be due to the circumstance that

[1] R. Wagner, *Chem. Techn.*, 9 edit., 1873, ii, 235.

some manufacturers use Gay-Lussac's column for absorbing the nitrous acid, whilst others work without it.

For the determination of the oxygen various apparatuses have been latterly introduced, especially arranged to permit of accurate tests being executed by a common workman.

Winkler has justly pointed out[i] the great technical value of gas analyses, and has described an apparatus which he has designed for the purpose.

Max Liebig[ii] has also accurately described another very serviceable apparatus for the same object.

Particularly interesting, both theoretically and practically, are the researches of R. Weber, of Berlin, on the theory of the manufacture of sulphuric acid. His first publication on this subject bears the date 1862. He[iii] analyzed the so-called "chamber-crystals," and assigned to them the formula, $HOSO_3+NO_3SO_3$, or, according to the present notation, $HSO_4+N_2O_3SO_3$. The accuracy of this composition has been since confirmed by other chemists.[iv]

In subsequent memoirs Weber[v] enlarges on the chemical process in the chambers; he points to the action of the nitrous acid, and assumes various reactions, according to the greater or smaller quantity of steam.

Kolb[vi] expounds the different theories on the manufacture of sulphuric acid in historical succession, and holds that Peligot has given the best explanation of the process. The last mentioned chemist pointed out in 1844 that "chamber crystals" were never formed during successful working. He maintained that the sulphurous acid was oxidized to sulphuric acid by the nitric acid, and represented the process in the following series of equations:—

$$NO_5+SO_2+ag = NO_4+SO_3+ag$$
$$2NO_4 \quad +ag = NO_3+NO_5+ag$$
$$3NO_3 \quad +ag = 2NO_2+NO_5+ag$$
$$NO_2+2O \quad = NO_4$$

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[i] Winkler. *Journ. f. Prakt. Chemie*, vi, 301.

[ii] Max Liebig, *Dingl. Pol. Journ.*, ccvii, 37.

[iii] R. Weber, *Journ. f. Prakt. Chemie*, lxxxv, 423.

[iv] Rammelsberg, *Bul. Chem. Ges.*, 1872, 310.

[v] Weber, *Pogg. Ann.*, cxxvii, 543, and cxxx, 329.

[vi] Kolb in his work cited in Jour. Frank. Inst., ciii, 271.

Transposed into the present notation these formulæ appear as—

$$N_2O_3+SO_2+H_2O=N_2O_4+H_2SO_4$$
$$2N_2O_4+\quad H_2O=N_2O_3+2(HNO_3)$$
$$3N_2O_3+\quad H_2O=4NO+2(HNO_3)$$
$$2NO+\quad O=N_2O_4$$

Winkler[i] assumes that the process of sulphuric acid making depends essentially upon the reaction between sulphurous acid and hyponitric acid in presence of steam. According to his view there is formed a compound of sulphuric acid and nitrous acid, which sinks to the bottom in the form of a white mist, often observed; comes then in contact with the hot dilute chamber acid, and is dissolved therein, when nitrous acid is liberated and oxidizes a fresh dose of sulphurous acid, and is thereby converted into nitric oxide. This, in turn, seizing the free oxygen present is re-converted into hyponitric acid and commences its circulation anew.

Hasenclever, in his treatise on roasting furnaces,[ii] assumes that the reaction takes place in such a manner that sulphurous acid and nitrous acid in presence of steam form sulphuric acid and nitric oxide, which latter is then re-converted into nitrous acid by the air, thus rendering the process continuous.

Fr. Bode[iii] maintains that this view of Hasenclever transgresses the logical laws of thought, though, since, according to his formulæ, the decomposition and re-formation of nitrous acid must go on simultaneously under the same conditions, and that it is, moreover, contradicted by the view of Winkler, and by known chemical laws. Here we must remark, however, that, according to Bode's view, every theory of the formation of sulphuric acid must offend against the logical laws of thought, whether we consider, with Berzelius, that it is nitrous acid, with Winkler that it is hyponitrous acid, or with Peligot that it is nitric acid, which hands over oxygen to the sulphurous acid.

It is incontestable that nitric oxide gas is repeatedly oxidized and reduced in the chambers, and, though we must certainly assume that decomposition and recomposition go on simultaneously, it does not by any means follow that they must take place under identical condi-

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[i] Winkler in his work cited in Jour. Frank. Inst., ciii, 271.

[ii] Hasenclever, *Zeitschr. d. Ver. Deutsch. Ing.*, 1870, 706.

[iii] Fr. Bode, "Beiträge zur Theorie und Praxis der Schwefelsaure," Berlin, 1872.

tions. Molecules of steam, oxygen, nitrous acid, sulphurous acid, and sulphuric acid in an atmosphere of nitrogen traverse the chamber from end to end. According to Schwarzenberg's calculation of the percentage composition of the entering gases when working with pyrites, there are 53·5 volumes of oxygen to 46·5 volumes of sulphurous acid. At the very outset of the process, therefore, there are present in the gaseous mixture more molecules of oxygen than of sulphurous acid. In the further progress of the reaction the proportion of oxygen must increase, since in the formation of sulphuric acid only 1 volume of oxygen is removed from the mixture for every 2 volumes of sulphurous acid. As soon as a molecule of nitrous acid is reduced to nitric oxide, the reducing sulphurous acid disappears from its immediate vicinity, whence oxidation is at liberty to set in when the gaseous mixture enters the vacuum formed by the formation of sulphurous acid. If, then, during the further progress of the reaction, the molecules of nitrous acid and of sulphurous acid come again in contact, the formation of sulphuric acid and of nitric oxide is repeated, which latter is again transformed into nitrous acid. The oxides of nitrogen are therefore chiefly present in the chamber in the state of nitrous acid, less abundantly as nitric oxide. In fact, the faint yellowish color of the gases in the chambers, where it can be observed by means of skylights and side windows (*e. g.*, in the sulphuric acid works at Nienburg), supports this view.

Hasenclever assumed nitrous acid as the oxidizing agent for sulphurous acid, because, according to Weber's investigations, nitric oxide gas and oxygen in presence of hydrated sulphuric acid and even of an excess of oxygen, do not form hyponitric but nitrous acid, and because Winkler has detected sulphurous acid as predominant among the gases passing from the chambers into the Gay-Lussac tower.

So long, however, as among the various theories of the formation of sulphuric acid in the lead-chambers, successively proposed by Berzelius, Davy, de la Provostaye, Peligot, Weber, Winkler, etc., no one has been definitely established by exact experiments, we must content ourselves with the view given by Clément and Désormes[1] at the beginning of the century:—"Thus nitric acid is merely the instrument of the complete oxygenation of the sulphur.

[1] Clément and Désormes, *Ann. Chim. Phys.*, lix, p. 329

It is its base, nitrous gas, which takes the oxygen from the atmosphere to offer it to the sulphurous acid in a suitable state."

Weber has also made interesting observations on the loss of nitre. He showed that losses of nitric acid might ensue not merely from the escape of nitric oxide and nitrous acid, but that in presence of an excess of water, nitrous acid is readily reduced by sulphurous acid to nitrous oxide. Fremy[1] also found that in the gases entering the chambers nitrous acid may be reduced to nitrous oxide, and even to free nitrogen if the sulphurous acid is too hot and too concentrated. Kuhlmann reported on this subject to the jury of the Vienna Exhibition, and writes, at length, to Dr. Hofmann as follows:[ii]

"In the manufacture of sulphuric acid the behavior of nitric oxide has been the subject of much investigation, but some points are still unexplained. The two following questions require an answer:

"1. In what circumstances is nitric oxide converted into nitrous oxide?

"2. Is such nitrous oxide the sole product which can be formed on the reduction of nitric oxide by sulphurous acid?

"In order to solve these questions it seemed advisable not to study the reactions in the chamber, but to submit the action of sulphurous acid upon nitric oxide in the absence of air to an accurate investigation. The two gases always act more or less upon each other, the sulphurous acid becoming oxidized to sulphuric acid by the oxygen of the nitric oxide. In order to ascertain how far this deoxidation of the nitric oxide can be carried, platinum sponge was introduced, which greatly facilitates the reaction between gaseous bodies. Nitric oxide may be in this manner reduced to nitrogen with formation of a corresponding quantity of sulphuric acid:

$$SO_2 + NO = SO_3 + N.$$

"Even without platinum sponge this reaction takes place, though incompletely. Even at ordinary temperatures some sulphuric acid is formed, and the more the heat rises the more energetic becomes the mutual reaction of the gases. It is possible that before the complete reduction of nitric oxide to nitrogen, nitrous oxide may be formed in

[1] Fremy, *Comptes Rendus*, lxx, 61.

[ii] Private communication.

the first place, but it is essential to note that the reduction does not come to a standstill with the formation of nitrous oxide. If sulphurous acid is brought in contact with nitric oxide at an elevated temperature, a complete reduction to nitrogen occurs. In these transformations the temperature plays an important part. In sulphuric acid works care must be taken that the gases do not act upon each other at too high a temperature, and the decomposition of nitre in the hot gases of the kilns must be absolutely condemned. If Glover towers are used for concentrating the chamber acid, they must be supplied with an acid as free as possible from nitrous acid; otherwise conditions are produced resembling those of the nitre decomposition just mentioned, where the reduction goes too far."

In fact the loss of nitre, with a complete absorption of the nitrous acid, in the Gay-Lussac tower, leads us to suspect that under certain circumstances reduction to nitrous oxide or nitrogen must take place. For the practical utilization of the experience collected in the laboratory, it will still be necessary to ascertain at what degree of condensation of the gases, and at what temperature the above-mentioned reduction ensues. Kuhlmann's observations may hold good in many cases, but they are not universally valid, since, according to the author's experience, some works consume a minimum of nitre, although the decomposition is conducted in the sulphur kilns and in the flues leading from the pyrites furnaces to the chambers.

(To be continued.)

Protection against Insects.—A soap, insoluble in water, may be prepared by mixing castile soap with a solution of sulphate of alumina, sulphate of iron, or sulphate of copper; copper making the mixture green, iron leather-colored, alumina colorless. It may be applied by melting, or by solution in petroleum or other volatile hydrocarbons. If the solution is not perfectly fluid, it should be warmed.—*Papier-Zeitung*, March 8. C.

Copper in Canned Peas.—M. Pasteur examined fourteen boxes of canned peas, bought at random in the principal quarters of Paris, and found that ten of them were colored by copper. Where there is no artificial coloring, the tint is always yellowish. There is no way of giving a green shade without adding a salt of copper. C.

WHAT I KNOW ABOUT LATE IMPROVEMENTS OF THE MICROSCOPE.

[Read before the Biological and Microscopical Section of the Academy of Natural Sciences, Philadelphia, June 4th, 1877.]

By JOSEPH ZENTMAYER.

A recent paper, by our fellow-member, Dr. J. G. Hunt, entitled: "Post-Centennial Microscopical Notes," read before this section, and published in the Cincinnati *Medical News*, has provoked considerable discussion, especially that part relating to my "American Centennial Microscope." As some of these important improvements have been claimed by other makers, I propose to bring the subject before you for investigation, with the endeavor to right the matter satisfactorily to all concerned.

In order to make the investigation a thorough one, it will be necessary for me to call your attention to the so-called Grand American Stand, made for this academy in October, 1859, and which now stands before you. The novel points of this stand, which I claimed at that time, were: 1st. The stage, with graduated revolving plate to serve as goniometer. Although very firm, it is only $\frac{3}{16}''$ thick, and is, even at the present date, the thinnest mechanical stage made. 2d. The graduated revolving base for measuring the angular apertures of objectives. 3d. The hanging of the mirror to a joint as near as possible to the plane of the stage.

Early in 1860, I made three stands (Nos. 13, 14 and 15) precisely like the Grand American, but somewhat lighter. No. 15 was made for a gentleman who was not in favor of mechanical stages, and who desired me to design for him a revolving stage, the object to be moved by hand, and it was for him that I constructed the first of my graduated stages, giving a complete revolution in the optical axis, *in a large ring, which is adjustable within another by three screws*, in order to have the axis of the stage coincident with the optical axis of the instrument, exactly the same as the one before you, which I made early in 1866. This stage has been for years extensively copied, in France and in England.

The hanging of the mirror by a joint as near as possible to the stage, I adopted long before I made the Grand American Stand. The first large stand I made has such a swinging mirror.

The microscope, to which I will now call your attention, is one which I made in 1864; the owner has kindly loaned it to me for this evening. The accompanying photograph was made in November, 1864. It is one of my army hospital stands, almost the same as made to-day, except that a sliding sub-stage is attached to the prismatic mirror bar, to receive the accessories. In the photograph you see an achromatic prism for oblique illumination (an apparatus which since then has also been brought out as new). Although handy as a mechanical contrivance, it is not of much importance; the mirror stem is only jointed near the stage, and has not the object under observation as its precise centre. If it had, it would be exactly the same as the swinging sub-stage and mirror of my new "Centennial Stand." About two years ago, in a conversation with Dr. J. G. Hunt, he pointed out the importance of having an arrangement for illuminating the object by an Achromatic Condenser in an oblique position. I explained to him how I would make a stand, in which this idea would be carried out in the most complete manner. The design and drawings were made soon after, but the instrument was not brought out, as I intended it for the Centennial Exhibition. Some of you have seen it before, and previous to bringing it to the exhibition, you recollect, it was shown at our meeting here, in April, 1876.

Messrs. Bausch & Lomb, of Rochester, N. Y., exhibited at the Centennial, a microscope stand with glass stage (a modification of mine); the mirror was hung to a swinging arm, and a diaphragm was attached to the mirror stem, quite similar to the instrument and photograph before you, made 13 years ago. The joint was *not* in a plane with the object, but below the surface of the stage, and the diaphragm was attached to a lateral slide, in order to make use of it when the mirror was hung obliquely, which is a clear proof that the joint was *not* in a plane with the object. I admit that in the way they accomplished it, they could have placed the joint higher, as they did in instruments brought into the Centennial Exhibition at a later time, but at a loss of extreme obliquity. To bring their mirror over the stage is utterly impossible.

A few days ago Dr. J. G. Hunt showed to me a letter received from Mr. W. H. Bulloch, of Chicago, accompanied by cuts and photographs. Dr. Hunt had the kindness to hand the photographs and cuts over to me, and I lay them before you. One photograph shows that Mr. Bulloch has adopted my circular, graduated, *adjustable* glass

stage, claiming this old invention of mine as his own. According to his statement he made it first in July, 1870, just 10 years after I introduced it.

The large cut and the other photograph represent his large Binocular Stand, also with adjusting screws to the adjusting revolving stage. The mirror stem is apparently stationary, and the mirror is attached to it by a double joint, permitting of some oblique illumination. But the important part of this instrument is an arc below the stage, which is traversed by the sub-stage. The centre of the arc is evidently in the plane with the object, and therefore the sub-stage can be placed radial to the object, provided the somewhat complicated mechanism is made and used with care. The angle of obliquity, of course, is a limited one, and even with a stage as small and thin as my Diatom Stage, it would not be possible to obtain, either with mirror or condenser, an angle sufficiently great for the present requirements. As the *mirror does not swing with the sub-stage*, it is difficult to get the mirror centered with the condenser. The photograph is marked 1873, making it evident that it is the first attempt to place the achromatic condenser in an oblique position to the optical axis. But comparing this arrangement with mine, as designed and adapted to my stands, the difference in the results, although involving the same principle, will be seen at once. The design of Mr. Bulloch is a heavy, costly attachment, limited in its movement, and unhandy, as the mirror does not follow the sub-stage, and when the mirror is used alone it is of no use whatever. In mine the mirror and sub-stage movement is only limited by the body of the microscope, and can be used below or above the stage, *always* having the object at its centre, and in such a simple way that not a single extra piece is added to an instrument with the ordinary swinging mirror; hence we can adapt it to our cheapest microscopes. Mr. Bulloch claims to be the first to use the mirror above the stage instead of the bull's-eye. According to his own statement, in 1870, I can only say, if Mr. Bulloch did not accomplish it before that time, that he is the last one I know of, who invented it. Spencer, Tolles, others and myself did the same thing many years before; and the little so-called Candlestick Stand, made and presented to our section by Mr. Ed. Tilghman, about 18 years ago, is capable of doing the same thing. Some accomplish it by detaching, others by adding, joints to the mirror. If accomplished in this way it is not worth the sacrifice of stability which is incurred.

DESCRIPTION OF ZENTMAYER'S AMERICAN CENTENNIAL MICROSCOPE STAND.

This stand was designed and constructed especially for the Centennial Exhibition. It is mounted on a tripod, with revolving platform. The bar and trunnions are one piece, and swing between two pillars for inclining the instrument to any angle. The swinging sub-stage, which carries the condenser (or other illuminating apparatus), and the mirror, swing around a pivot, the axis of which passes through the object observed, so that the object, in every position of the sub-stage, is in the focus of illumination.

The stage is attached to the stand by a spindle, which passes at a right angle through the axis of suspension of the instrument, and is firmly fastened in position by the milled head nut in front.

The large rotating stage may be removed and replaced by one especially constructed for extreme oblique illumination, called a diatom stage, and the swinging illuminator may then be used for illumination from above. The sub-stage is provided with a graduated circle (on the collar of the swinging arm) for indicating the degree of obliquity of illumination.

As an object placed on the stage is in a plane with the axis of the trunnions, it is obvious that, if the instrument is placed in a horizontal position, the object is in the axis of revolution of the graduated platform, and the angular aperture of an objective focused on this object can be easily measured. In this position the object is in the centre of all the revolving parts of the instrument, the revolving stage, swinging sub-stage, and the platform.

The principal stage is similar to that introduced by Mr. Zentmayer in 1860. It was the first stage provided with adjusting screws for accurate centering and revolving in a large outside ring, thus giving facility for oblique illumination and graduation to serve as a goniometer.

The sub-stage is divided into two cylindrical receivers, to facilitate the adaptation of several accessories at one and the same time; the lower cylinder of the two can be moved up and down or entirely removed.

The adjustable concentric diatom stage is 3 inches in diameter, and extremely thin, allowing, in connection with the swinging sub-stage and mirror, not only the greatest oblique illumination, but the mirror and achromatic condenser can be swung above the stage for illuminating opaque objects.

B.

NOTES ON COMPENSATING-POWDER.

By Lieut. CHAS. A. L. TOTTEN, U. S. Army.

The construction of the 81-ton gun has been accomplished only through a masterly subjugation of the difficulties attendant upon great-gun manufacture. There are, however, very few insurmountable mechanical difficulties, and the success with which these have been met and subdued simply gives us new evidence of progress in modern art. But perhaps this is the chief merit that England can claim for her achievement, since it is doubtful whether as a *step* in cannon construction it possesses any other very valuable feature.

No *new*[1] ballistic principles were discovered during the experiments with it at Shoeburyness, nor was its origin founded upon any new theory of cannon manufacture. It is constructed of the same materials used in all English guns, is "built up" in a similar manner, uses the same explosive in proportional charges and grains, and gives evidence of possessing all the *disadvantages*, as well as the advantages, of its many predecessors. The hereditary weakness of this family of guns appears to be inevitable, and advices from abroad state that the interior tube of the 81-ton gun has cracked, thus early, in the same way as do those of all Woolwich cannon.[2]

There is a definite relation existing between gunpowder and gun-metal, and gun strength or safety depends upon its due recognition. This relation must enter as a vital condition into the equation of every cannon, and as *definitely* into that of the great-gun, as it does into that of a toy. But no new conditions were impressed upon the Woolwich equation to realize the 81-ton gun; simply larger quantities were substituted and correspondingly greater results obtained.

The tables of fire as reported from these experiments at Shoeburyness, give no appreciable gain in initial velocity.[3] Such a deficiency, in so costly a gun, is noticeable from the fact that the safe

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[1] Several "re-discoveries" have been made, but no markedly new points have been brought out. See *Army and Navy Journal*, Vol. XIV, No. 21, page 329.

[2] *Army and Navy Journal*, Jan. 20, 1877.

[3] As supporting this statement, see *Army and Navy Journal*, Jan. 27, and Feb. 24, 1877; and *Benton. Ord. and Gun.* Page 565.

Table 3, Roberts' Hand Book, latest edition (1875), gives 1561 feet I. V., as the

attainment of a greater initial velocity than has thus far been realized, is perhaps the vital problem of modern ballistics. Money has been persistently wasted in the vain endeavor to obtain valuable results from *defective* gun systems, while the important question of velocity would not seem to have received its due share of attention.

In view of the shortcomings of the 81-ton gun, this problem now presents itself with renewed interest, and urges us to lay aside for a moment the troublesome question of construction, and turn our attention once more to that of a *suitable* motor power.

The expression,

$$\frac{M V^2}{2g}$$

represents the energy of a projectile; in which M stands for mass, and V for velocity. If we cause either of its factors to vary, while the other remains constant, we will affect its value, and accordingly as V or M becomes the variable factor, the circumstances of impact will alter. In the one case we shall have the same projectile moving with varying velocities; in the other the velocity will remain the same, while the projectile will alter. Let M and M', V and V' represent respectively the masses and velocities of two similar projectiles, made of the same material. Let

$$\frac{M V^2}{2g} = \frac{M' V'^2}{2g}.$$

But let M be greater than M', then will V be less than V', and though the actual amount of work performed will be the same in both cases, it will be accomplished differently. The energy of the larger, heavier projectile, will be lost in the shock of impact, it being distributed slowly over a large surface, while that of the

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maximum, and the others ranging from 1000 to 1500 feet, for the British cannon that preceded the 81-ton gun.

Holley, in Table XXVIII, holds to about the same figures for the rifled guns, and to some 1600 for the smooth bore guns of the same service.

The initial velocity given by the larger Varvasseur guns (Table 5, Roberts), varies around 1200, 1400 or 1500 feet.

Similar initial velocities—1400 to 1500 ft.—are ascribed to the efforts of the Krupp gun. Table 6, Roberts.

We can, in fact, fairly assume that the initial velocity to be expected of a projectile, fired from the best guns, and with their proper service charges of *gunpowder*, can hardly exceed the normal one of 1500, or at the most, 1600 feet. Greater power exists in the powder, but we cannot afford to strain the gun and so have to sacrifice it.

smaller and swifter one, will be expended in penetration. There result from this consideration two great ballistic systems, known as the American or Racking system, and the English or Punching system. The former has to deal with mass, and endeavors to determine the largest projectile which can be impressed with a normal velocity; the latter studies velocity, and seeks to know the greatest initial impetus which can be imparted to a given projectile. "Smashing" effect is the desideratum of the one, penetration that of the other.

Other things being equal, it belongs to the punching system to improve gun strength and efficiency, while the racking system should study gun size and construction. These considerations, however, are almost the opposites of the ones that have determined the experiments of the rival schools. Strangely enough, each has seemed to be most interested in the problem of the other, and English experiment in particular, while it has not noticeably advanced the cause of the punching system, has clearly established the practicability of the racking.

The Woolwich gun has grown in size, but the relation between charge and projectile has had no opportunity to alter, and therefore very naturally the recent experiments at Shoeburyness, show no increment in velocity. The absolute effect is, of course, greater, but it is manifestly due to the racking element of its enormous projectile.

In the meantime, though America has done very little in the experimental line, she has carefully studied both systems. She is not ready to abandon her own, but has certainly decided favorably for rifling, breech-loading, and gun strength, all elements belonging to the punching system.

But all of this experiment and study has been based upon the supposition that the motor power has been perfected, that we have developed all the possibilities of gunpowder, and satisfactorily established the inadaptability of the detonating class of explosives, for artillery purposes, and that, therefore, we must accept gunpowder as the primary starting point in all future artillery improvement.

It was but a few years ago that grains of mammoth powder, less than an inch in diameter, were regarded as enormous. Its introduction into artillery use added a noticeable feature to its modern phase, but the step once taken suggested others leading to even more decisive results, until to-day we find the large-grained powder

thoroughly tested, and, in some form or other, generally adopted. So far from being surprised now at a cubic inch of powder, we deliberately handle and expend grains or masses weighing pounds. Improvement in gunpowder has kept pace with cannon improvement, until, practically speaking, the former has been perfected. Its proper composition has long been known, its most suitable grain-shape studied, its density thoroughly investigated, and the best methods of its manufacture pretty certainly arrived at. The phenomenon of its explosion is sufficiently well understood to make its use absolutely safe and certain. In its various forms of prismatic powder, pellet, hexagonal, perforated cake, and others, we find this fierce explosive agent handled in a way so masterly, that its almost lightning change of state from a solid to a gas is, practically speaking, under our control. Of course we do not mean that in these studies we may not to some extent still improve, but that it is a matter of reasonable doubt whether absolute perfection in all of them would materially increase its present power, and satisfy the demand for such a projectile agent as a 100-ton gun certainly requires.

Among the large class of explosives more violent than gunpowder, none, perhaps save gun-cotton, has been found in the least degree suitable for artillery use. They have been studied carefully, but all of them have been found too sudden in their action—they strain a gun too severely. Austria, indeed, almost curbed gun-cotton for artillery use, but, whether woven or granulated, its rate thus reduced in a wonderful degree, still even this, the most tractable of all the detonators, has proved more than a match for the best of guns, and, we understand, its special patron has at last abandoned it and returned to gunpowder as perhaps alone practicable.

It is of little consequence how great the absolute working power of an explosive be, provided we can regulate its application. Could we but concentrate the whole force of a charge of nitro-glycerine upon the projectile, there could be no better agent for artillery use, but how to do it is the question. It is not so much that a given gun will not sustain this or that pressure, but, that it cannot offer the same resistance to a *blow*, as to an increasing and continued pressure of even the same intensity. For instance, a gun which would burst disastrously under a pressure of 50,000 lbs., due to the explosion of nitro-glycerine, might stand the same pressure from one of gun-cotton, and possibly be quite within the limits of safety for an equiv-

alent charge of gunpowder in its most approved form. The dangerous element in the phenomenon of explosion is its *rate*.

Philosophers have confidently asserted that, rapidly as it moves, the earth could be put in absolute rest, and without shock, in a few minutes. Everything is relative. So, too, in the phenomenon of explosion, can we but govern it during its brief duration, so that its action shall be an *acceleration* instead of a *shock*, we shall solve the first problem of modern artillery. This problem is to find an explosive of such capacity and character, and in such form and condition, as will give a maximum impetus to the projectile while it exerts a minimum strain upon the gun. Primarily, then, it must be an accelerator, a composition such that, while it possesses all the energy of the detonating class, shall nevertheless curb that energy in the first instants of its action, and concentrate it upon the projectile. It can rule the projectile but a moment; this moment over, its influence is but a dying echo. In this brief instant the projectile must rise in a relatively gradual scale through all the stages, from absolute rest to great velocity. If this can be accomplished, it is manifest that for the same charge we shall strain the gun less. We shall focus, as it were, the whole force upon the projectile, and for the same reason the latter will receive the utmost velocity that the given charge can impart. From this standpoint the action of gunpowder is best studied under the form of the perforated cake, which we will briefly examine.

Explosion in the case of gunpowder is a true combustion: it burns regularly inwards, though rapidly, layer by layer. The amount of gas developed depends directly upon the extent of the burning surface. If the size of the grains be increased while the weight of the charge remains constant, there will be less surface exposed to combustion, and the amount of gas evolved in the first instants of time will be diminished; consequently there will be less pressure on the breech of the gun. This principle led the late General Rodman to perforate powder grains of large size with numerous small holes, for the passage of the flame. The powder thus burns upon an increasing surface, the gas continually gains intensity, the gun is not so severely strained, and the normal velocity is retained. Here, then, is a true accelerator.

The latest American powder, hexagonal, and the English, cubical, the latter used in the 81-ton gun, are steps in retrograde. They are

not accelerators—this principle has been sacrificed to the attainment of density and uniformity. These forms of powder beautifully illustrate the relation between a large surface of combustion, and a diminished strain upon the gun, and thus fulfil their mission; still they are but temporary expedients. It is different, however, in the case of the perforated cake. Powder thus treated conserves its force well, and strains the gun towards the minimum, and for this reason it has very naturally been adopted by one of the greatest military powers in Europe, for use in the strongest gun. In the meantime, with the detonating class of explosives we have been mainly engaged in reducing the intensity of their action, nor have any of them yet come within the limits of artillery requirements. Explosion in the case of gun-cotton is not combustion: it is more of a disintegration, a loss of equilibrium, taking place, as it were, instantly throughout the entire mass; the outer portion does not seem to protect the interior, as is the case in a large grain of gunpowder.[b]

Gunpowder and gun-cotton are respectively the best representatives of the two great classes into which explosives may be divided—mechanical mixtures and chemical compounds. We have briefly referred to them separately; let us now glance at them comparatively, and follow the suggestions of their study to some legitimate conclusion.

Gunpowder ignites at about 570° F., while gun-cotton will explode at 360° F.; the former may be used as an igniter for the latter. Equal weights of the two substances can be put in such condition as to occupy about the same space. They are chemically neutral to each other. As to absolute force, gun-cotton is from 3 to 7 times more powerful than powder, weight for weight.[i] They are both

[b] There are two orders of explosion, and gunpowder and gun-cotton are each susceptible to both; the former, however, favors true combustion, while the latter is most liable to detonate. * * * * Ordinary explosion is the mechanical progress of an impulse from atom to atom of the substance itself; detonation is the rapid transmission of this impulse through some other medium, as it were, and reaches all the atoms practically at once—in the one case we have successive, in the other, instantaneous action. "The rapidity with which gun-cotton detonates has been computed at 20,000 feet per second." (Knight.) "The velocity of combustion of dry French war powder is found to be 0·48 inches, and of English powder, which American powder closely resembles, about 0·4 inches." (Benton.)

[i] "In experiment with a Krupp's, cast steel, 6 pounder, a service charge of 30 oz. of powder produced an initial velocity of 1338 feet; a charge of 13½ oz. of gun-cotton produced 1563 feet."—*Holley. Ord. and Armor*, 793.

We regard gun-cotton in this paper as having an intensity 4, gunpowder being

stable substances; neither of them is subject to serious change under ordinary atmospheric conditions, and of the two, *gun-cotton* is the least alterable from such influences. Relatively speaking, gun-cotton is no more liable to explode from friction or percussion than gunpowder; these substances are, in fact, the safest of their respective classes, and gun-cotton itself is by no means the *dangerous* substance generally supposed.[c]

Both of these explosives possess valuable resources for the artillerist, yet neither of them fulfils in itself all the requirements of a projectile agent. While powder has considerable, gun-cotton has almost unlimited power; the explosion of the former can be governed, that of the latter has hitherto been unruly. But the very means we take to curb the first-force of powder, reduces to a minimum its already relatively small power-capacity. If we could obtain an explosive whose action would be similar to that of hexagonal powder until the projectile had taken up a rapid velocity, and which should then burn up with all the energy of gun-cotton, we would have a most valuable accelerator.

"How can these two substances—gunpowder and gun-cotton—be used in combination?" This question, asked of the writer by a brother officer some years ago, suggested a method which resulted in a joint invention that has received the name of "Compensating-Powder."[d] The idea is to "build up" grains, cakes, or masses out

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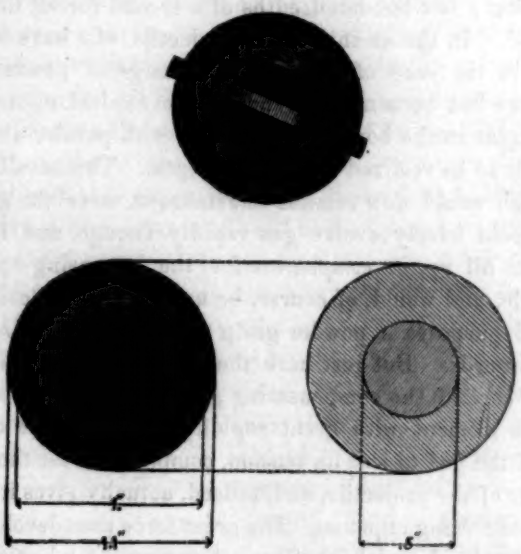
unity. It must be noticed, however, that in the employment which we shall make of this material, its relative force (as a minimum) is of but little consequence. Gen. von Lenk has discovered the means of giving gun-cotton any velocity of explosion that is required, and any force from one to seven. This depends upon its mechanical condition. Abel's disk may be much more powerful than Austrian woven, or spun gun-cotton, and the more powerful the better for our purpose.

[c] It must of course be understood that we are discussing these substances under their most reliable and latest known conditions. Of the stability of *good* powder there can be no doubt; of that of gun-cotton, in similar condition, we have unimpeachable assurances from the highest authorities. See notes on explosives by Prof. Hill, and testimony of Baron von Lenk, the famous Austrian experimenter on gun-cotton, before a special committee of the British Association, on the characteristics and explosive properties of this substance. See *Report of British Association*, 1863.

[d] The compensating-powder was discussed at the Artillery school several years ago, it being the joint invention of two officers (1st Lieuts. A. E. Miltimore, 1st Artillery, and Charles A. L. Totten, 4th Artillery, U. S. Army), then on duty with the class at Fortress Monroe. The matter lay in its crude form for some time, owing to changes of station and press of other duties, until the detail of the writer to this institution,

of two or more explosives, or out of the same explosive in varying conditions, in such a manner that these explosives shall be ignited *successively* by the actual combustion of the several layers down to them. For instance, suppose we have a large grain of such powder; its form, for discussion, is immaterial; let it be a sphere of gun-powder an inch in diameter, and imagine it to possess an interior and concentric core of gun-cotton one-half an inch in diameter. Such



a grain would be constructed with a scientific regard to the peculiar characteristics of each substance, and would evidently burn upon the accelerative principle. Let us examine the theoretical combustion and effect of a charge of such powder fired in a gun. The relative amounts of the two explosives would satisfy the demands of the compensating principle (to be noticed later) and at the same time the

offered special facilities for study, the consultation of scientific men, and the further development of the idea. It is still more or less theoretical, and while both of these officers fear that it is, perhaps, published too early, still the step is rendered advisable for many reasons known best to themselves. It is worthy of being fairly examined by military men, as at least an interesting attempt at the solution of an important problem, and one that, even should it fail to realize its own promises, may suggest to others the direction in which to take this all-decisive step in modern artillery—the one in search of greater initial velocity, coupled with a minimum strain upon the gun.

reasonable precaution of reducing the more explosive substance to its minimum effective quantity. Immediately after inflammation the gunpowder would commence to be rapidly consumed in towards the cotton. The exterior layer burning first would prepare the way for the more violent explosion of the interior one, and being itself in large grains, would offer a minimum surface to combustion during its first and most decisive instants. The powder part of the grain would thus be suited to large charges and guns.

It takes but a few one-hundredths of a second for all the powder to be consumed. In the meantime the projectile will have acquired its motion as in the case of the ordinary charge of powder alone, for thus far there has been no difference in the explosion, and will have reached a point in the bore beyond which, with powder alone, no material gain is to be realized from gun length. The small amount of powder which would now remain unconsumed, were the grain homogeneous, would barely evolve gas rapidly enough and in sufficient quantities to fill up, or *compensate* for, the increasing space behind the projectile, and would, of course, be useless for acceleration. For all practical purposes a powder grain might as well be *hollow* from this point inwards. But just here the valuable part to be played by the interior core of the compensating grain is to be noticed. Exploding at this moment with great rapidity and force, it checks any tendency of the gas to lose its tension, compensates for the increasing space in rear of the projectile, and, indeed, actually gives it a final and valuable accelerating impetus. The great force thus developed by the gun-cotton in this last stage will not be exerted against the walls of the gun, as would be the case in the explosion of a charge of gun-cotton alone, but will evidently be directed towards the line of least resistance thus artificially prepared for it. The cotton, in fact, will find a condition of affairs in the bore of the gun that is especially favorable for its action. It is no longer confined to a space just sufficient to contain it before combustion, but finds a continually increasing one into which to expand, a cushion of gas against which to impinge, and an already rapidly moving projectile to accelerate. In the summer of 1876 the residence of Prof. Gœssmann, at Amherst, Mass., was struck by lightning, which in its course through the house paid a very marked deference to one of the fundamental laws of force. The fluid came down the chimney, burst out into a second story room, *and passing along the gilt border of the wall-paper*, bored its way through the

opposite side of the house without deranging the room in the slightest. The inappreciably thin metallic layer of this gilt border was all-powerful! If lightning, a force so violent and swift, is still obedient to this simple law, it is obvious that the explosive impetus from the interior core ought likewise to seize so opportune a line of least resistance.

In the employment of mammoth powder, even in its most approved form, we have to contend against a very serious element—*wastage*. These large grains are found to be only partially consumed; still burning, they are thrown out of the gun along with the projectile. That is, when the combustion has reached a certain point the projectile leaves the gun, and all the powder remaining unconsumed is wasted. This waste reaches the enormous amount of 60 per cent.! The introduction of an interior core of higher explosive properties can be made to do away with this expensive loss. Forty pounds of powder do all the work in a service charge of one hundred pounds.[1] Reckoning gun-cotton as only four times the strength of gunpowder, fifteen pounds of it would be equivalent to the sixty pounds of powder that are wasted. If, then, we imagine this amount of cotton introduced as a core into the forty *working* pounds of powder (the size and number of grains remaining the same), we shall have a charge stronger, by the equivalent of sixty efficient pounds, than the present service charge of the 15-in. "Rodman gun." It must be remembered, moreover, that such a charge will expend its first forty pounds in impressing the projectile with its present normal velocity (1500 or 1600 feet), and that the remaining fifteen pounds (*once and a half the value of the first forty*) of force generator, will work under the most favorable circumstances as a pure accelerator. We shall thus eliminate the great waste of the one, curb the straining action of both, and obtain a true *artillery powder*,—lighter, and four and one-half times more effective, charge for charge, than our best gunpowder.[2]

(To be continued.)

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[1] In this calculation we have taken a low estimate. "Bunsen and Schischkoff determined that the waste in gunpowder is 68 per cent. of its own weight, and that only 32 per cent. is useful. In a 100 lb. charge, a portion of the 32 lbs. of the useful powder-gas must be employed in impelling a 68-lb. shot composed of the refuse of the gunpowder itself."—*Holley. Ord. and Arm.*, 789.

[2] So long as we use gunpowder, we must, of course, contend against an unavoidable percentage of waste, but regarding this (which we do here to simplify the argument)

Osmotic Action in Fishes.—When fishes are removed suddenly from fresh to salt water they generally die. Felix Plateau thinks that the sea-water acts as a poison, but Paul Bert attributes their death to osmosis. A frog, plunged in sea-water, loses a third of his weight; if only the paw is immersed, blood globules escape from the vessels and spread under the skin. Salmon, in such a sudden change, live longer than most fresh-water fishes, but they succumb after five or six hours. Hence it is probable that, in their migrations, they gradually accustom themselves to the changing density of the water. Fresh-water eels are exceptions to the general rule. M. Bert cites a fact which shows how easily errors may be made in laboratory experiments. He had repeatedly plunged fresh-water eels in salt water, and having always found them alive after many days, he left the experiments to his office boy, when he found that the eels always died within three or four hours. On investigation he found that his boy took the eels in a napkin, and thus wiped away some of the mucus, which commonly protects the skin from the injurious effects of the water.—*Les Mondes*, March 29. C.

Water-tight Cement.—A good waterproof cement is made by dissolving five parts of gelatine in hot water, and adding one part of chromate of lime. The cement must be kept in vessels which are well shielded from light.—*Der Practische Maschinen Constructeur*, 1877, No. 5. C.

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as coming entirely (as it does mainly) from the loss of the unburned portion, we have the means of eliminating it. If, however, we are to argue strictly, then, allowing 18 spheres to the pound, we have 388·8 grains as the weight of each, of which 58·3 grains are the weight of the core, and 330·5 that of the jacket. Were this a homogeneous sphere of powder, 40 per cent., or 155·5 grains, would do all the work and 233·3 be wasted. But reckoning the relative value of cotton as 4, the core of this sphere (none of which is wasted) is equal to 233·3 grains of powder, and as 132·2 grains of the powder jacket *are* effective, we have 365·5 grains as the effective powder-value of this sphere. If we take cotton at 7, we have for this value 540·0 grains! In the one case we have an absolute loss of only 23·8 grains, in the other an absolute gain of 151·2; in the former we have a *relative* gain of 210·0 grains' work, in the latter, one of 384·5.

So many conditions, which do not at first appear, will enter this problem, that to consider the question in its mathematical bearings alone would require all our space. No attempt is made, therefore, to elucidate the intricate questions of relative size of jacket and core, their resulting densities, the dependent rates of combustion, etc., etc. These are all intimately related to each other and to the general question, and will be studied with interest by those who wish to investigate this matter of *compensation* deeper.

CONCERNING INDICATOR DIAGRAMS.

By Paul Kauffer.

[Translated from *Dingler's Polytech. Journal*, by Henry H. Suplee, S. B.]

In the majority of writings upon the steam engine, diagrams are used just as they are taken by the indicator, but this is not altogether correct. For the simple calculation of the gross power of an engine, the diagram may be used in its original form, but not if it is desired to ascertain the effective pressure exerted upon the piston at every point of the stroke; as, for example, when it is desired to determine the proper mass for the beam, fly-wheel and other moving parts, that they may have sufficient inertia to overcome the inequalities of pressure.

Fig. 2.

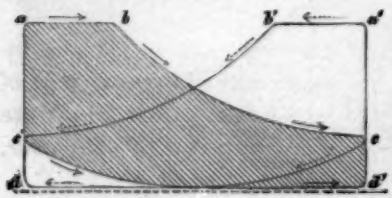
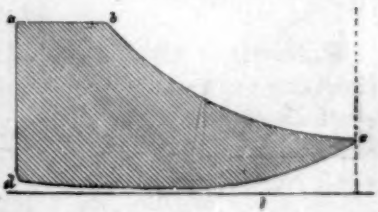


Fig. 1.



Every diagram consists of a curve of work and a curve of resistance, and these two curves are not traced at the same time; but, for example, the curve of work is taken in the passage from left to right, and the curve of resistance in the return from right to left. In order to indicate a working cylinder, I use, wherever it is possible, an indicator on each end of the cylinder, and it was the analysis of just such a case that first showed me the necessity of the following correction:

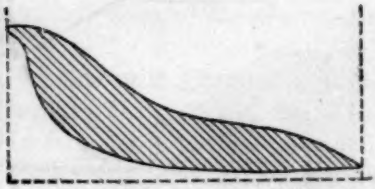
In Figs. 1 and 2, I have endeavored to show the case as clearly as possible. The valve was set quite correctly, and the diagrams from each end were very similar. The diagram from the left end, Fig. 1, is marked in Fig. 2 by the letters *a*, *b*, *c*, *d*, and that from the right end by the letters *a'*, *b'*, *c'*, *d'*. It must now carefully be noticed that during the stroke of the piston from left to right, the curves *a*,

b, *c*, and *c'*, *d'*, will be drawn simultaneously. There is, therefore, at the beginning of this stroke, a pressure upon the piston equal, not to *a d*, as in the uncorrected diagram, but to *a c'*; and the back pressure at the beginning of the stroke will no longer be null, as in Fig. 1, but will be equal to *c' d*. The arrows show the direction of the stroke from that point, moving from left to right.

Of course, the correction is just the same for the right hand diagram, as shown by the dotted arrows. The difference is now quite apparent between the shaded diagram of Fig. 2 and the uncorrected diagram of Fig. 1. If the valve is carefully set, so that the diagrams from both ends are alike, it is a very simple matter to make the correction, as it is only necessary to reverse the resistance curves.

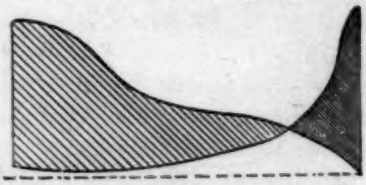
I give some further examples, in order to show the value of this correction. Fig. 3 is a diagram from Bauschinger's "Indicator Ex-

Fig. 3.



Original.

Fig. 4.



Corrected.

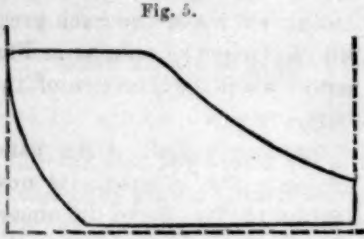
periments on Locomotives," and Fig. 4 shows this diagram as corrected. A single cylinder would hardly be able to make such a diagram at all, as the mass of the moving parts would have to be disproportionately large in order to store up enough living force at the beginning of the stroke to overcome the resistance at the end, as shown by the dark shading of Fig. 4. According to Fig. 3, the curve of work could hardly be more uniform, but in Fig. 4 it is quite otherwise.

With Fig. 1 the case is just the reverse. A balance-wheel, calculated from Fig. 1, would be much too heavy, since the variation of pressure appears much greater in Fig. 1, than when corrected in Fig. 2.

This correction would soon relieve many engines of the unnaturally high compression with which they are working. A glance at Fig. 4 shows the injurious effect of such compression. In order to show this

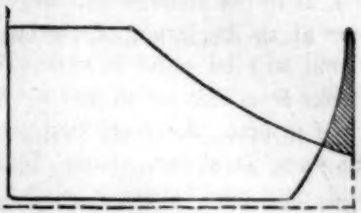
by some examples, I have taken Figs. 5 and 7 from Radinger's

Fig. 5.



Original.

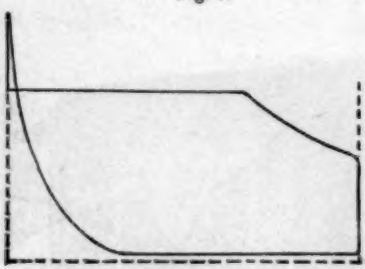
Fig. 6.



Corrected.

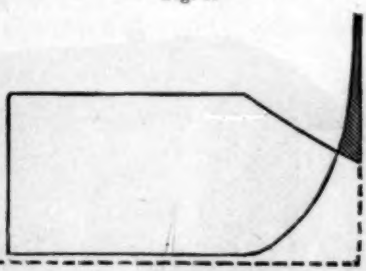
valuable work on the steam engine. These two diagrams are given just as they were taken from the engine. By their side I have

Fig. 7.



Original.

Fig. 8.



Corrected.

placed the corrected diagrams, and I will leave it to the reader to judge whether such compression is as advantageous as it seems to have been considered till now.

Recovery of Platinum.—Mons. E. Duvillier recommends the following method of reducing the platinum from the chloroplatinate of potassium: 100 grammes of the chloroplatinate, 50 grammes of dry formiate of soda, 50 c. centimetres of soda at 30° B.; boil in about 1 litre of water.—*Acad. Sc.*; *Les Mondes*, March 15. C.

Cure of Chronic Anæmia by Transfusion of Blood.—M. Oré reports a case of anæmia of five years' standing, induced by nervous and digestive troubles, which was effectually cured by the transfusion of 40 grammes of blood. He considers the blood as acting in two ways: 1, by stimulating the action of the enfeebled organs; 2, by favoring the growth of new globules. C.

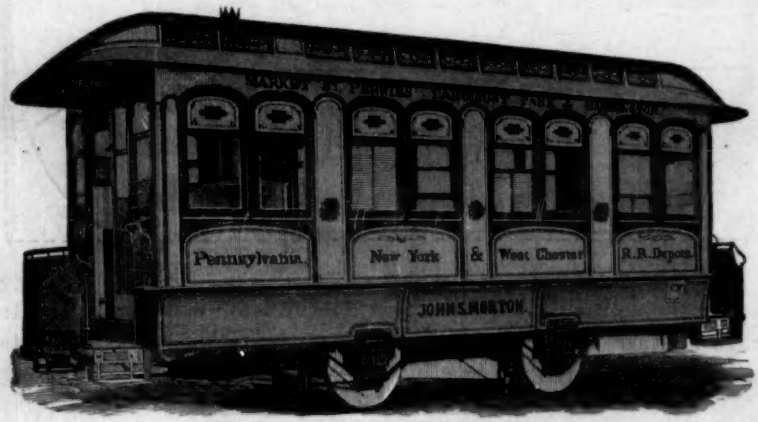
STEAM ON STREET RAILWAYS.

II.

Extract from the Secretary's Report, at the Meeting of the Franklin Institute, May 16th, 1877.

In furtherance of the proposition to lay before you such information as is available regarding the progress making toward the general introduction of mechanical propulsion on street railways, you are here presented with illustrations on the screen, of the steam street car invented by Mr. Louis Ransom and built by Messrs. Gilbert, Bush & Co., of Troy, N.Y. Six of these cars (Fig. 1) were placed on the Market Street line in this city on March 21st, 1877, and

Fig. 1.



have run with considerable regularity to this time, over what is known as the Baring Street branch, which has maximum grades of about four and one-half per cent., and many curves.

These cars are 16 feet long in the clear inside, and have a seating capacity for 20 persons, but are very frequently loaded with 50 persons.

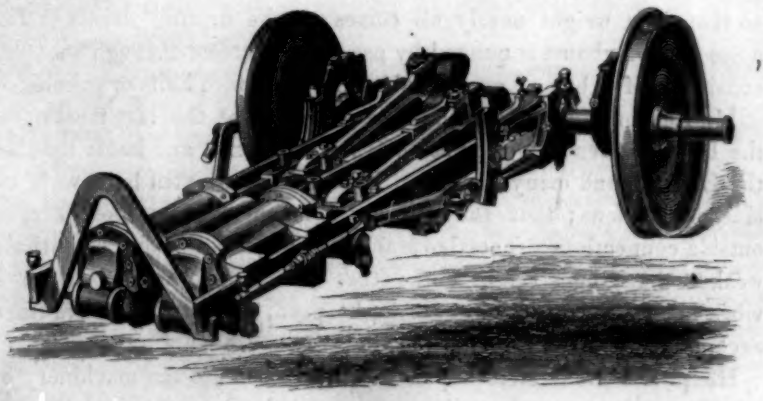
They have a wheel base of 7 feet, rather more than the ordinary horse-car, by which it is claimed there is less *teter* in passing over rough or uneven places in the track, although it increases the friction in passing curves.

The boiler is upright, with shell 37″ diam. by 56″ high, made of one sheet of No. 1 charcoal hammered iron, and contains 300 upright

tubes 1¼″ diam. and 12″ long, and has 116 square feet of heating surface and 6½ square feet of grate. The boiler is tested to 200 lbs. pressure per square inch, and its working pressure is 120 lbs. The steam room in the boiler is 26 times the capacity of one engine cylinder.

The engine (Fig. 2) is a double one, having steam cylinder 5¼″ diam. and 14″ stroke. The two cylinders are cast in one piece, and have attached to them three bars which extend to, and are connected by journal boxes to, the crank axle, thus forming the framing of the engine. By this arrangement all the working strain of the machinery is brought on these bars or frame, and not on the frame of the car body. The slide valves are operated by a link motion and two eccentrics to each cylinder. The link is not raised or lowered as in the more general practice, but oscillates on a pin at one edge and midway of its length of the link. The valve rod is attached to a

Fig. 2.



pin in the link block, which is moved up or down to reverse the engine or vary the rate of expansion. The reversing lever is placed in the corner of the car in front of, and convenient to, the engineer's right hand. One end of the engine is supported by the crank axle, which is placed at the after end, and the forward or cylinder end of the engine is supported by a bale passing over a strong bar attached to the bottom of the car body. The usual straight axle supports the forward end of the car, but its wheels are not coupled to the driving wheels. The whole propelling apparatus, being supported at three points, is not easily racked or injured by derailment, gives great flexibility and is easily removed in case of extensive repairs; when

slight repairs are needed the car can be run over a pit, the front end of the engine detached and allowed to hang down from the crank axle like a pendulum. The machine is also accessible for cleaning, oiling, packing, etc., through trap-doors in the floor of the car.

There is attached a steam brake with a cylinder 3½ inches diameter and 8 inch stroke. The piston rod is extended into a rack which works in a geared sector. From pins in the sector, connection is made by links to knuckle-jointed levers, forcing the brake shoes against the inner edges of the wheels. The lever of the brake throttle is so arranged with reference to the engine throttle lever, that the act of shutting off steam from the engine, opens the brake throttle, thus enabling the engineer to perform both these acts with one short stroke of the hand. The boiler is placed a little forward of the front axle and the water tank under the floor at the rear end. The space for passengers is about equally divided forward and aft of the hind axle, so that their weight nearly all comes on the driving wheels. The noise of the exhaust is quieted by passing the steam through a muffler consisting of a box of considerable size filled with balls or pebbles.

Mr Ransom differs from the view expressed at the last meeting of the Institute, regarding the use of the crank axle, and holds that all the English, and many American Locomotives are still built with inside connections; that they impart a much steadier motion than outside connections; that the crank axles do not prove essentially weaker than the straight ones; that outside connections cause a vibrating motion to the car at high speed, and have no advantage except ease of access to the working parts.

He places great stress upon the injury done to the machinery of all steam street cars, from its exposure to the dust of paved streets, and estimates the cost of repairs from this cause alone (if not guarded against), as a large percentage of the entire cost of operating such cars. To overcome this he has enclosed the machinery in a box or casing so perfectly dust-tight, that after running all day through the dusty streets, the engine is not only free from dust, but covered with drops of water, condensed from the slight escape of steam from the stuffing boxes. The facility with which the machinery can be so enclosed, to protect it from dust, he claims as another advantage in the use of the crank axle for street cars.

These engines can be applied to old car bodies, as it is only necessary to raise the rear end of the car so as to run out the axle,

and put the engine crank shaft in its place, and attach the front end of the engine to the bottom of the car; provision would of course have to be made for the boiler.

In January, 1876, one of the Ransom steam cars was put on the Coney Island Railroad, extending from city line to Gravesend, a distance of 4½ miles, where it run 81 miles per day for 5 months. The round trip of 9 miles was run in 40 minutes, and then the car stood 50 minutes. The consumption of coal was 600 lbs. per day, or 7·4 lbs. per mile. This car was submitted to severe trials before and after its regular work at Coney Island, and was afterwards sold to, and is now running on, the Onondaga Valley Road, in Syracuse, N. Y.

The question of consumption of coal by the cars now running on the Market Street line, has not yet been determined satisfactorily, but Mr. Ransom hopes that it will be less than that mentioned above. The entire cost of running 81 miles per day, is, however, estimated at $8.31 per day.

Some difficulties have been encountered in running the present cars on the Market Street road, which the inventor says arose principally from two causes. First, he expected to have them run on the main line, and did not know of the many curves and steep grades of the Baring Street branch, over which these are running, and the 5¼ inch cylinders proved to be too small; they should have been 7 inches diameter, and the builders are now making them of that size for such service. Second, the peculiar, greasy mud of such a city as this, causes the ordinary chilled, cast-iron wheels to slip, and to overcome this, he purposes hereafter to use steel tires on the driving wheels.

When these and some minor changes are made, the inventor is very confident that his steam cars can be operated at a cost greatly below that of horse cars.

French Railway System.—In a memoir of M. de Franqueville, M. F. Jacqmin reviews the relations between the railways and the State, in different countries, coming to the conclusion that France alone has solved the difficult problem of reconciling these two grand principles: authority and liberty. The whole territory of France is divided into six grand railway-departments, in each of which, with a few unimportant exceptions, all the railways have been conceded to a single company.